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STATEMENT

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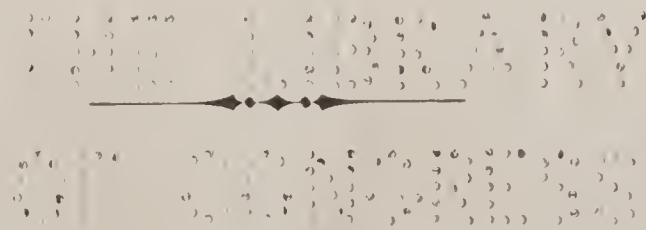
BEFORE

THE SUBCOMMITTEE OF THE COMMITTEE ON
INTEROCEANIC CANALS,

UNITED STATES SENATE,

CONSISTING OF

SENATORS MORGAN (CHAIRMAN), HANNA, MITCHELL, TURNER,
AND FOSTER OF LOUISIANA.



WASHINGTON:

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WATERFALL

WATERFALL

ISTHMIAN CANAL.

WASHINGTON, D. C.,
Wednesday, February 12, 1902.

The subcommittee met at 10.30 a. m.

Present: Senators Morgan (chairman) and Hanna.

Also, Senators Platt, of New York, Hawley, Harris, Millard, and Kittredge, members of the committee.

Mr. George S. Morison appeared and was duly sworn by the chairman.

STATEMENT OF MR. GEORGE S. MORISON.

The CHAIRMAN. Mr. Morison. Senator Harris is our engineer member of our committee, who is somewhat familiar with that Peninsular country, having surveyed it when he was a young man, in connection with his father, who is an engineer, and so I will ask him to conduct the examination so far as you are concerned.

Senator HARRIS. Mr. Morison, you are a member of the Isthmian Canal Commission?

Mr. MORISON. Yes.

Senator HARRIS. I do not remember whether you were the member of the Commission who made some special examinations as to the route down on the Isthmus of Darien or not. I think you were.

Mr. MORISON. I was. I went along the whole coast from what is commonly known as Panama to the mouth of the Atrato.

Senator HARRIS. The Isthmus of Darien proper is that portion lying below Panama, between that and the mainland?

Mr. MORISON. I have never been able to determine what the Isthmus of Darien was. When I was a boy the whole isthmus was called Darien. In our classification we called the routes east of Panama the Darien routes.

Senator HARRIS. I wanted to ask you some questions in regard to those routes east of Panama, through the shortest portions of the isthmus and ending in Caledonia Bay, the Gulf of Panama, San Miguel Bay, etc., those all involving a tunnel.

Mr. MORISON. Yes; everything we could find there would involve a tunnel. The lines across from Caledonia Bay are the ones which have generally been called the Darien routes. The line across from San Blas has been known generally as the San Blas route.

Senator HARRIS. But they are both on that route?

Mr. MORISON. They are a considerable distance apart. This little bit of a map will perhaps show you the location. That little map which I produce shows in a condensed form where those routes are. You will notice that all of them terminate on the Gulf of Panama, and that practically they are all the same distance from the common point that has to be made to get around the Azuero Peninsula.

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Senator HARRIS. Of course all of those routes come under the concession which the Panama company has?

Mr. MORISON. Yes; they all come within the territory in which the Panama Canal Company has an exclusive right to build a canal.

Senator HARRIS. And therefore all of those routes would require the same legal and diplomatic negotiations to be gone through with that are involved in the case of the Panama line proper?

Mr. MORISON. I should say so.

Senator HARRIS. I believe you mentioned three of those routes in the report; the Sassardi location, the Aglaseniqua location, and the Caledonia location.

Mr. MORISON. Those are three variants, you may say, of the Caledonia route, or what was generally called the Darien route. They cross the summit of the range, which is very near the coast, at the heads of different valleys. They all come together at or before the connection with the Savana River, which is the Pacific outlet.

Senator HARRIS. You also have a fourth one, the San Blas.

Mr. MORISON. That is the San Blas route.

Senator HARRIS. Now, in all of these practically there are good harbors?

Mr. MORISON. Yes; they are all good harbors.

Senator HARRIS. And of course the distance is shorter between tide levels than by any other route?

Mr. MORISON. The distance on the San Blas route is shorter. The distance on the Darien route proper, that leading from Caledonia Bay, is quite as great as it is on the Panama route.

Senator HARRIS. You estimate, I see, on the Sassardi location for 40 miles of railroad. You give the distance from Caledonia Bay to the mouth of the Lara, varying from 32 miles by the Sassardi route to 36 by the Caledonia route.

Mr. MORISON. Yes. That does not take you to deep water. You have got to improve the Savana River and put in a tide lock at a considerable distance below that. That must be included in the distance between deep waters, and that makes it more than the Panama route.

Senator HARRIS. By the San Blas route the distance from tide water to tide water is 21 miles.

Mr. MORISON. Yes; from tide water to tide water, but not from navigable water to navigable water.

Senator HARRIS. That is what I meant in the other case. It does not mean from the six-fathom line, or anything of that kind.

Mr. MORISON. No, sir.

Senator HARRIS. These have advantages in the way of being sea-level canals and having available harbors!

Mr. MORISON. Yes.

Senator HARRIS. But on account of the one vital piece of work, impracticable apparently, according to the ideas of the Commission—that is, the tunnel—they were not recommended!

Mr. MORISON. That was so. We considered that the objection to a tunnel was so great that it outweighed all of those matters very much.

Senator HARRIS. So that a route may have the advantage of shortness, and yet there may be a vital piece of work which will render it unavailable?

Mr. MORISON. That is true.

Senator HARRIS. In regard to those tunnels, I think you estimate the cost of excavation in the tunnels at \$5 per cubic yard?

Mr. MORISON. Yes.

Senator HARRIS. Do you think it is possible that that can be done at a lower rate than \$5 per cubic yard?

Mr. MORISON. Yes; I do.

Senator HARRIS. It has been stated that it could be done for very much less.

Mr. MORISON. I think it is possible that it could be done for less. I think the chances are that it would cost more. You see, we do not know what it is, and there is nothing more unsafe than to guess at things that nobody has ever seen. In order to make anything like an accurate estimate of what it would cost to build a tunnel there that whole line should be bored. I have not any definite idea of what kind of rock would be found, and I do not think anybody else has.

Senator HARRIS. I was going to ask you whether you had any information at all as to the geological character of the ridge to be tunneled.

Mr. MORISON. The presumption is that it is volcanic rock, that it is something like what is found everywhere else on the Isthmus, what is found, you may say, on the Coast Range all the way from Oregon to Panama. That is, it is largely basalt; but at the same time other rocks may be found there. It is a country of geological disturbances, and I do not think you can form any judgment that is worth anything as to what kind of rock it is, or as to what it will cost to excavate it; or, in fact, whether you can excavate it as a tunnel, until the line has actually been bored.

Senator HARRIS. You think that the probabilities are that it would be very much broken up and full of faults and a great deal of unstable material?

Mr. MORISON. I do.

Senator HARRIS. You do not think there is any human probability of its being a solid wall of granite?

Mr. MORISON. I should be very much surprised if it was, but I would not say that it is not.

Senator HARRIS. I am speaking of probabilities. What indications did you observe there of the presence of granite to any considerable extent?

Mr. MORISON. I did not go back to the ridge. I only went along the coast. I talked with the men that went back to the ridge, and I saw what there was on the coast. There was nothing I saw which indicated to me that there was granite there, and I do not think I saw any granite on the Isthmus, either at Nicaragua or Panama, or around there.

Senator HARRIS. Even if along the line of a survey granite should be noted in the field books here and there, you would not consider that a reliable indication that there was a solid wall of granite?

Mr. MORISON. No, sir; and even if I knew that the entire isthmus was granite I should not feel that it proved that it was a solid mass of granite, for you find faults and cracks and all kinds of things in granite.

Senator HARRIS. Even in the western mountains, where granite prevails everywhere, we find it broken up in every possible way.

Mr. MORISON. Yes.

Senator HARRIS. With other material.

Mr. MORISON. Yes. We considered what we thought could be done if that ridge was of a good solid rock in which excavation could be made, and on that basis we made our estimate.

Senator HARRIS. And you regarded it as necessary to provide for lining the tunnel?

Mr. MORISON. Yes, by all means. I never should be willing, I think, to send canal traffic through a tunnel that was not lined, even if it was the best granite tunnel I ever saw. I may mention an instance in point. It is not the case of a granite tunnel, but of a limestone tunnel on the Nashville and Chattanooga Railroad, which had what was virtually a perfect roof, a flat roof of solid limestone, which in many respects is better than granite, because the hard limestone strata were all the right way. That roof stood for fifty years, and then began to fall to pieces.

Senator HARRIS. Through atmospheric action and jarring, and so on?

Mr. MORISON. From some cause or other.

Senator HARRIS. All of these things are factors.

Mr. MORISON. There are a great many factors, and the tunnels in granite countries have generally required more or less lining. Then the dropping of a rock in a railroad tunnel is a very different thing from the dropping of a rock on a ship or under a ship. One of the hardest rocks through which we have done any tunneling is the rock of Bergen hill, back of Jersey City, where the Erie tunnel goes, and where the Delaware, Lackawanna and Western has a tunnel. There are several. The Susquehanna and Western has one. That is a solid trap rock, and the Erie tunnel has been in use about fifty years. Yet the other day traffic was interrupted there for hours and a train wrecked. I suppose Senator Platt knows that tunnel very well.

Senator HARRIS. The Panama line was not regarded by the Commission in their first report as the one which they desired to recommend, and apparently—I should like to know if that is correct—the change in their opinion grew entirely out of the reduction in the price at which the property of the Panama Canal Company could be obtained.

Mr. MORISON. Well, I can speak only for myself in that respect. I never should have signed any report recommending the Nicaragua route in preference to the Panama route except on the ground that I felt that the United States could not afford to be held up by a French organization.

Senator HARRIS. The reduction in the price asked for to \$40,000,000 made it come within what you thought was a legitimate and proper price?

Mr. MORISON. I think that is a perfectly proper price. I think our Government could have better afforded to pay twice that price than to have built the Nicaraguan Canal, if that had been the whole question; but the United States Government, as I look on it, has many other things to do than to build an interoceanic canal; and if it allows itself to be imposed upon through an unreasonable price for one piece of property, it may be for some others, and that feeling was what settled my decision. I felt that these French people had put themselves in a position in which we could only treat them as you would treat an oriental trader—tell them that we could not have anything more to do with them if that was the way they talked.

Senator HARRIS. In the final report, Mr. Morison, you mention a great many difficulties which are still to be removed.

Senator HAWLEY. The thing that sticks in my crop, as the slang phrase is, is that if we pay \$40,000,000 for that we shall find a lot of

liens upon it and have 60 per cent to pay on the dividends, if there are any, and we shall have a perfect barnacle load of claims from the French people.

Mr. MORISON. I do not see how those could come at all. I do not see how there can be anything of that kind.

Senator HAWLEY. I think we should have a new set of French spoliation claims.

Mr. MORISON. I can not see how those can come.

The CHAIRMAN. Can you see how they can be avoided?

Mr. MORISON. I do not see how they are going to arise. I think everything of that kind has been settled. It is more than ten years since the collapse of the old French company.

Senator HAWLEY. It is a century since the collapse of the other French claims.

Mr. MORISON. I do not know the conditions of those other claims. I can not say anything about them.

The CHAIRMAN. Have you finished your answer?

Mr. MORISON. Yes.

The CHAIRMAN. I interrupted you for the purpose of ascertaining what you referred to when you said that there were other matters that the United States had to deal with that were of greater concern than even the digging of a canal, if I understood you.

Mr. MORISON. Yes.

The CHAIRMAN. What other matters are those?

Mr. MORISON. I did not have any particular matters under consideration, but I do consider that our Government is going to do a great many other things, that we shall put ourselves in a position where we have got to make purchases from foreigners. I do not refer to canals at all.

The CHAIRMAN. I know you do not refer to canals, and that is the reason I asked you the question. I wanted to know what you did refer to.

Mr. MORISON. I do not refer to anything specific. A case came up recently which is of this order. That is the purchase of the Danish Islands. I do not know what may come.

The CHAIRMAN. You have mentioned some considerations that influenced your judgment in coming to a conclusion in this matter.

Mr. MORISON. I feel that it is important that the United States Government should keep itself in a position in which it is understood that it is not giving what people ask unless it considers it reasonable.

The CHAIRMAN. Have you in your studies of this question contemplated or considered the question as to which of these Governments, Nicaragua and Costa Rica on the one side and Colombia on the other, will grant us exclusive canal privileges at the lowest cost?

Mr. MORISON. I do not know anything about it directly. My impression is that you can do quite as well with Colombia as you can with the other Governments.

The CHAIRMAN. I want to know if you have considered this proposition. You seem to have a poor opinion of everybody down there.

Mr. MORISON. Yes.

The CHAIRMAN. The French, and also the Spanish, if I am right about it?

Mr. MORISON. I think that things have been rather badly handled down there in a great many ways.

The CHAIRMAN. Have you, in your reflections about this matter, trying to reach a conclusion that was valuable and of importance to your country and your Government, considered the proposition of a combination between Nicaragua, Costa Rica, and Colombia to fix a price for exclusive privileges upon that isthmus, and to divide the swag, if you please to call it that, between them?

Mr. MORISON. No; I have not.

The CHAIRMAN. You have not thought about that?

Mr. MORISON. I have not.

The CHAIRMAN. You see now, do you not, that it could be very easily done?

Mr. MORISON. I do not believe it could be very easily done, under the present political conditions down there. It is a thing that might be done.

The CHAIRMAN. It is only the political conditions that are in the way?

Mr. MORISON. I do not see anything else.

The CHAIRMAN. The financial difficulty could be very easily removed by paying \$40,000,000 or \$50,000,000 to the two Governments and letting them divide it, could it not?

Mr. MORISON. I do not know that I am prepared to say how you would handle those Governments. I think I would rather leave that to you, gentlemen.

The CHAIRMAN. So that your opinions, I suppose, as between the two routes, have been based very largely upon what you supposed we could do in acquiring exclusive privileges for canal concessions in either country?

Mr. MORISON. That is a very important factor. I am an engineer myself, and I have looked at this subject from an engineering point of view.

The CHAIRMAN. That is what I supposed.

Mr. MORISON. So far as political rights are concerned, I have considered, assuming the Maritime Canal concessions to be absolutely void, and all rights to have disappeared, that the ground was clear for treaties on the Nicaragua route.

Senator HANNA. Well, is it clear?

Mr. MORISON. It is on that assumption; not on any other.

The CHAIRMAN. Now, I will not interrupt Senator Harris's examination any further.

Mr. MORISON. I have considered that the situation in Colombia was complicated by the circumstances of those prior concessions; that those prior concessions were such that the United States Government could not do anything under them. They are not concessions under which this Government could afford to build; but they were a cloud on the title. At this act of their holders proposing to transfer everything to the United States Government removes that cloud. It gives us an opportunity of getting the desired rights from Colombia. Now it simply leaves the field as clear at Panama as the assumption just made leaves it at Nicaragua. It does no more. The ability of the United States to build a canal in either place must be determined by subsequent treaties; and my judgment is not worth much as to which country you can make better treaties with.

The CHAIRMAN. There is one question which has not been at all mooted here that I want to ask you about. The State of Panama,

under the Wyse concession and under the extension, has a specific right to an annual payment of money by this canal company, and also by the railroad company to that State. Now, in order to get rid of what we call the cloud on the title, is it not necessary also to deal with the State of Panama aside from the Republic of Colombia?

Mr. MORISON. I am not sufficiently familiar with the constitution of Colombia to say. Colombia was formerly supposed to be a federal republic. Its name was the United States of Colombia. It was in that condition when those specific rights of Panama were created. Subsequently they changed the relations of the States and changed the title of their country, which is not now the United States of Colombia, but the Republic of Colombia. It is my impression, though I do not know, that the settlement with the State of Panama should be made through the Government of Colombia. The State of Panama is entitled under the railroad concessions to one-tenth of the annual payment, \$25,000 out of \$250,000.

The CHAIRMAN. Have you, in coming to that conclusion, taken into consideration the guarantee which we make in the treaty of 1846 of the sovereignty of the Colombian Government over that isthmus?

Mr. MORISON. No; I have not considered that particularly in making that answer.

The CHAIRMAN. We will refer to that later.

Senator HANNA. The chairman asked you a question there, if I remember it correctly, as to whether in coming to your decision as to the preference of these routes, you had been governed by the conditions of the concessions? I ask the stenographer to read the chairman's former question.

The stenographer read as follows:

"The CHAIRMAN. So that your opinions, I suppose, as between the two routes, have been based very largely upon what you supposed we could do in the way of acquiring exclusive privileges for canal concessions?"

Senator HANNA. What I wanted to ask you, as to the choice or practicability of routes for canal purposes, the getting of the concessions was a necessity in either case; and from an engineering standpoint, from the standpoint of the physical conditions, you were in favor of the Panama route, as I understand you?

Mr. MORISON. I am, and always have been so since I have seen the two routes.

The CHAIRMAN. Now, Senator Harris, will you proceed.

Senator HARRIS. Speaking of the reasonable price which the Panama people now ask, you regard the construction of a railroad, of course, as necessary to the construction of a canal. That has got to be done in either case?

Mr. MORISON. Practically so.

Senator HARRIS. That railroad, of course, would not be so expensive a road as a permanent commercial road?

Mr. MORISON. Yes; it should be. You have got to have a very good railroad if you are going to conduct your work properly.

Senator HARRIS. Well, the equipment is not of as expensive a character.

Mr. MORISON. You want the very best equipment you can get if you are to handle large quantities of material economically.

Senator HARRIS. Certainly, you want an equipment of that character; but dump cars, flat cars, and all the machinery of that kind are not

so expensive as Pullman cars, or high-class passenger coaches and passenger engines.

Mr. MORISON. It is not as expensive as Pullman cars, it is not as expensive as high-class passenger cars; but the freight engines of to-day are the most expensive locomotives built, the powerful engines to haul heavy loads.

The CHAIRMAN. For great distances?

Mr. MORISON. Anywhere.

Senator HARRIS. Anywhere. Well, then, assuming that to be the case, what would you think would be the necessary cost of a railroad adequate for the doing of the work required in the construction of the canal?

Mr. MORISON. I think the estimate in the Commission's report is not far from right--\$75,000 a mile.

Senator HARRIS. That being the case, do you think it is reasonable for us to pay \$140,000 a mile for the Panama road?

Mr. MORISON. Yes, sir; all things considered, I do. The Panama Railroad holds something more than itself. It has something more than a railroad. The company have a good deal of other property, and they will earn a great deal of money from commercial business during the construction of the canal, whichever canal is built. They will not earn anything after the canal is completed.

Senator HARRIS. Do you think that the amount they would earn in the construction of the canal and the doing of this work would more than pay off the indebtedness which now hangs over them?

Mr. MORISON. Yes; I do.

Senator HARRIS. There is a considerable indebtedness aside from the stock which hangs over that road.

Mr. MORISON. I think the indebtedness is stated in detail in the supplemental report of the Commission. I think it is correct.

Senator HARRIS. I suppose you did not consider the difficulties involved in the United States Government becoming a stockholder in this New York corporation, the Panama Railroad Company?

Mr. MORISON. I considered that there was a method of handling that without much difficulty.

Senator HARRIS. You regard the vital piece of work on the Panama Canal, of course, to be the Bohio dam?

Mr. MORISON. I think the vital piece of work is the Culebra cut.

Senator HARRIS. Do you think that is more difficult?

Mr. MORISON. Yes; I do.

Senator HARRIS. And that there are greater uncertainties involved in the Culebra cut?

Mr. MORISON. No; I do not know that there are any great uncertainties in either case, but it is a very great mass of work.

Senator HARRIS. Do you think it would take longer to do it than the other?

Mr. MORISON. Yes.

The CHAIRMAN. Did you say there were any uncertainties in either?

Mr. MORISON. I do not think there are any serious uncertainties in either.

Senator HARRIS. Mr. Morison, here is an article which appears in the proceedings of the American Society of Civil Engineers, in which you say, alluding to the Bohio dam:

"It involves novel and untried features. Few engineers, even among

those who feel that they could construct it, would be ready to say in advance how the work would be done. The difficulties, taken in connection with the climate and other surroundings, are enormous."

Mr. MORISON. Yes.

Senator HARRIS. That, to me at least, indicates that there were some uncertainties. "Novel and untried features" would indicate uncertainties.

Mr. MORISON. Well, that certainly does indicate something in the way of uncertainties, I suppose. If you come right to the facts, I do not consider that the solution of the dam given by the Commission was the wisest one.

Senator HARRIS. Now, Mr. Morison, if you will kindly, in your own way, state what you think generally are the objections to the general plan of the Bohio dam we shall be glad to hear your statement.

Mr. MORISON. I think it is unnecessarily expensive; that is the principal thing. I think I see a method of solving the problem for very much less money and with no element of special difficulty.

Senator HARRIS. That is, you mean by the substitution of the plan which you indicate in this article published in the proceedings of the American Society of Civil Engineers, January, 1902?

Mr. MORISON. I do.

Senator HARRIS. Which is earth and stone?

Mr. MORISON. Yes.

Senator HARRIS. Practically?

Mr. MORISON. Yes.

Senator HARRIS. And sheet piling?

Mr. MORISON. That is of no particular importance. I put it in because I could. I thought it would be about as well to leave it out.

Senator HARRIS. You consider that really would not be of very much importance in preventing filtration?

Mr. MORISON. No, sir; I do not think it would be of importance. I think it is of very little importance anyway.

Senator HARRIS. That is a permeable material.

Mr. MORISON. There is a permeable material down in the bottom of the Chagres Valley. It is a question of how much you can afford to pay to cut off the seepage through that permeable material.

The CHAIRMAN. What particular class of material is it that you call permeable?

Mr. MORISON. Sand and fine gravel—material through which water will penetrate. It seemed to me that it was not worth while to pay a great deal, or to undertake very difficult work, for the purpose of cutting off that seepage.

Senator HANNA. The water would have to penetrate through what depth of clay before it would reach the sand?

Mr. MORISON. I do not feel sure it would have to penetrate any clay. I think very likely that the sand reaches the river at some point above; but it would have to run at least half a mile, and probably 2 miles through the sand, to get out at the other end.

Senator HARRIS. In your article you speak of the fact, demonstrating the connection between the river and this permeable material, being shown by driving a pipe down and the water rising to the level of the river in the pipe?

Mr. MORISON. Yes.

Senator HARRIS. And that shows, of course, there is a connection?

Mr. MORISON. Yes. Whether it is a connection above or below we do not know.

Senator HARRIS. Or at the side?

Mr. MORISON. It can not be at the side. We know that. It is a connection with the water in the river somewhere.

Senator HARRIS. Of course we have here the plan of the dam as recommended by the Commission, involving the sinking of caissons, and in this drawing they seem to let the upper edge of the caisson rest upon the stone, and a considerable of it below. That, of course, must be an error?

Mr. MORISON. No, sir; that is correct.

Senator HARRIS. Is that the way it is intended?

Mr. MORISON. Yes; but the space between that cassion and the stone would be filled with concrete; that is, that the sand would be cleaned out and other material put in.

Senator HARRIS. You would have to excavate until you reached the bed rock?

Mr. MORISON. Certainly.

Senator HARRIS. The entire width?

Mr. MORISON. To carry out that plan we would.

Senator HARRIS. And put in impermeable material, such as concrete?

Mr. MORISON. Yes.

Senator HARRIS. What is the limit of engineering experience in pneumatic work in this country—that is, the depth to which it has gone?

Mr. MORISON. There may have been some recent work of which I do not know the depth. The greatest depth at which I have ever worked men was, I think, 108 feet. They were worked to a depth of 115 feet at St. Louis.

Senator HARRIS. It has been stated that 110 feet was the limit there.

Mr. MORISON. It was over 110 feet at St. Louis. I have been told that pressures have been used which were equivalent to a depth of 130 feet, but that I am not positive about. This is from information and belief.

Senator HARRIS. This has been on work for foundations for bridge piers and dams, and work of that character?

Mr. MORISON. Yes; and some of it in tunnel work.

Senator HARRIS. And, of course, covered by the limits of one caisson?

Mr. MORISON. I do not understand your question.

Senator HARRIS. What I mean is this: This seems to provide for caissons, I think, about 30 by 100 feet.

Mr. MORISON. Yes.

Senator HARRIS. That is about the size of the excavations in the cases you speak of?

Mr. MORISON. I used a caisson at Memphis that, as I recall it, was 60 by 90 feet.

Senator HARRIS. That was for the bridge pier?

Mr. MORISON. Yes.

Senator HARRIS. There of course you had no problems with regard to any connection around it. You were simply sinking it down and getting a foundation for that area?

Mr. MORISON. Yes.

Senator HARRIS. Here of course the difficulty would be encountered in the connection of each caisson with the other?

Mr. MORISON. Yes; there would be some difficulty.

Senator HARRIS. So as to prevent water passing between?

Mr. MORISON. Yes; trying to make it absolutely tight.

Senator HARRIS. It would be desirable to make it absolutely tight, would it not?

Mr. MORISON. That would depend upon what it cost. I do not think it is very important to close the flow of water through that stratum down there alone. The calculations that I have made make me feel that it is not worth the cost.

Senator HARRIS. That is why in your plan you are trying to disregard some of the flow of water?

Mr. MORISON. Yes.

Senator HARRIS. You concluded it would not be dangerous?

Mr. MORISON. During the last few years a great many experiments have been made to determine the rate of filtration through sands. It is a comparatively new subject. It has been investigated with special care in Massachusetts, where they have had a double question. They have had the question of water supply for the metropolitan district, and other points in the State, and they have had the question of dams; their experiments have been carefully conducted, and very careful results have been worked out from them. They have prepared a formula which shows probably quite as accurately as any hydraulic formulæ do the rate at which water will filter through sands under various heads.

In the new Wachusett reservoir, on the Nashua River, above Clinton, they have accepted that condition in planning one of their dikes, and are making no attempts to close an old geological channel which has sand in it away below the present surface of the ground. I have made various calculations on the amount of water that would pass through that permeable stratum below. I have shown my conclusions to the engineers who have done that work in Massachusetts. I have had the samples of sand taken from those borings analyzed by the man who made the analyses there for the metropolitan board of health, and the conclusion I have come to is, that there is no chance whatever that the filtration would exceed 40 cubic feet per second, and I should be very much surprised if it is over 10 cubic feet per second; I do not think you can afford to pay very much to get rid of that.

Furthermore, there are various ways in which I believe that sand could be made water-tight, but I do not believe it would be necessary. Various things have been done in the way of grouting sands with cement and with clay.

Senator HANNA. In that connection, you have made the dam feature a specialty in connection with the report of this Commission?

Mr. MORISON. I have studied it up a good deal. I dissented from the conclusion of the Commission that this dam was a piece of work of great difficulty.

Senator HAWLEY. What conclusion?

Mr. MORISON. The conclusion that that dam was a work of great difficulty. It seemed to me that it was not.

I did not consider it expedient to separate myself from the Commission on account of a single detail; but if I had been compelled to make a minority report, as I was at one time, when I had prepared one, I should have referred particularly to that point.

Senator PRITCHARD. How long have you been engaged in the business of engineering?

Mr. MORISON. Thirty-four years.

Senator PRITCHARD. What experience have you had during that time outside of this particular undertaking?

Mr. MORISON. Well, I have had a considerable variety of experience. I have done a great deal of work on Western rivers, and I have done more or less railroad work.

Senator HANNA. Have you been engaged in many operations connected with the sinking of caissons for foundations and for building dams and bridges?

Mr. MORISON. I have had a great deal to do with the sinking of caissons for foundations. I think I must have been chief engineer of more than 12 bridges in which that process has been used. I can count up now ten on the Missouri River alone.

Senator HANNA. So that your experience in that sort of work has been about as extensive as that of anybody in the country?

Mr. MORISON. My experience in caisson work has been.

The CHAIRMAN. What line of railroad on the Missouri River do you refer to?

Mr. MORISON. I built the bridge of the Northern Pacific at Bismarck, the Northwestern bridge at Sioux City, the Northwestern bridge at Blair Crossing, the Union Pacific bridge at Omaha, the Burlington bridge at Plattsmouth, the Burlington bridge at Nebraska City, the Burlington bridge at Rulo, the new bridge at Leavenworth. I overhauled the bridge at Kansas City and I built the Burlington bridge at Bellfontaine Bluffs.

Senator MILLARD. You built nearly all of them?

The CHAIRMAN. You built the Memphis bridge?

Mr. MORISON. Yes. I built the Cairo bridge and I was consulting engineer of the Merchants bridge at St. Louis.

The CHAIRMAN. Are you the consulting engineer of these other companies you mentioned, now?

Mr. MORISON. No, sir.

The CHAIRMAN. None of them?

Mr. MORISON. I have a sort of a nominal—a slight connection with the Chicago and Northwestern Railway, but it is not regular. They occasionally call me in. Then I built the bridge across the Snake River at Riparia, and across the Willamette at Portland, although I did not use the pneumatic process in that. I started to build a bridge across the Columbia River at Vancouver, and got one foundation down, when the panic came and stopped the work.

Senator HARRIS. With regard to the Culebra Cut, what do you think are the difficulties involved there?

The CHAIRMAN. Before you take up that, I wish you would ask Mr. Morison something about that temporary dam.

Senator HARRIS. The Commission have made an estimate for a temporary dam, preparatory to building the one at Bohio. Did they consider it unnecessary, or was it included in the estimate?

Mr. MORISON. It is included as a lump sum.

Senator HARRIS. You add a very considerable amount for that purpose?

Mr. MORISON. Yes; in the paper of mine which I see you have here, I wanted to go into a little more detail in the matter of a temporary dam, so that I might be sure that my estimate had an actual detailed basis, and the temporary dam which is described in that paper was

designed for that purpose. I considered that the plan would very probably be materially modified before it was built. It may be possible to build the dam without it; but I thought that the estimate should include it now. The Commission's estimate, I think, contains a round sum of \$500,000 for the temporary dam, and that amount was deducted from the estimate in the Commission's report for the Commission's dam in the price given in my paper.

Senator HANNA. In the construction of the dam, no matter what may have been the estimates and plans made originally, of course the engineers in charge of the construction might make changes and modifications, and would certainly take the precaution to prepare for any emergency or any conditions that might arise as the work was actually done.

Mr. MORISON. I should certainly think the engineers in charge of the work should have the right to make very material modifications.

In this connection there is another feature about the Panama Canal. Our examinations and estimates indicate that that canal can be shortened a mile and a quarter, and the expense lessened by so doing.

The CHAIRMAN. At what point?

Mr. MORISON. By running directly across from Bohio to Gatun instead of following the present valley of the Chagres—following the Panama Railroad and leaving the old valley of the Chagres as the line for the discharge of the water from the spillway.

Senator HARRIS. The French road follows the valley of the Chagres?

Mr. MORISON. Yes, sir. You mean the French canal?

Senator HARRIS. Yes; the French canal.

Mr. MORISON. That is the proper route for a tide-level canal. The conditions of a sea-level canal are different; but if you are going to build a canal with locks and turn the water into another channel, the indications are that this other route will be the better one.

But the Panama estimate was generally made on a rather liberal basis, and things of that kind were left out.

Senator HARRIS. You materially changed the French plans by taking out the French summit level entirely?

Mr. MORISON. Yes; we did.

Senator HARRIS. The French, I believe, had made borings in the Culebra Cut to the bottom of their summit level, to ascertain the quality of the material?

Mr. MORISON. They have made borings deeper than that. They had two plans, one with a summit level at elevation—I can give them only approximately—one with a summit level at elevation 125, and the other with a summit level at elevation 63 feet. They made their borings to the level of the bottom of the canal on the plan with the lower summit level.

Senator HARRIS. So that you think the quality of the material to be encountered in the Culebra Cut, in getting to the lower level required by the Commission plan, has been thoroughly uncovered and demonstrated.

Mr. MORISON. Yes; I believe it has.

The CHAIRMAN. With regard to the borings for the foundation of the Bohio Dam, they were about 50 feet apart, generally, I believe.

Mr. MORISON. They were rather more than that. I think they were about 200 feet apart. I could tell you exactly. There is a map that shows it. We bored over a considerable reach of country. This

plan shows the distance apart of the borings on the line of that particular dam. They are about 200 feet apart here.

Senator HARRIS. Borings 200 feet apart may leave very considerable contingencies to be accounted for in a more careful examination.

Mr. MORISON. In that class of rock they can. That is one reason why I felt gratified when I thought I had worked out a scheme which was independent of the result of such borings.

Senator HARRIS. You did not consider the determination of the bed rock there as sufficiently demonstrated?

Mr. MORISON. I think there may be holes which are deeper. I do not think they would do any harm, though.

Senator HARRIS. Well, those holes would probably be filled with this permeable material?

Mr. MORISON. Yes.

Senator HARRIS. The presumption is gravel and sand?

Mr. MORISON. Yes.

The CHAIRMAN. Mr. Morison, you speak of geological valleys. Do you understand how those valleys happen to be; whether they are the result of the flow of water through depressions, or of earthquakes, or of other dislocations of the bed rock or the bed material?

Mr. MORISON. No, sir; I do not. Some of them may be formed in one way and some of them in another.

The CHAIRMAN. As to this particular one, how is that formed?

Mr. MORISON. Well, I do not know.

The CHAIRMAN. You do not know?

Mr. MORISON. No, sir; I doubt whether anybody does; but still there are other people who may. A geologist would know more than I do.

The CHAIRMAN. I will ask you if you believe it might have been formed by water rushing down and carrying out the material?

Mr. MORISON. Not unless the whole level of the Isthmus was very much higher than it is now. The valley is well below the level of the sea, and you could not have water rushing down it to do that unless the valley itself was above the sea.

The CHAIRMAN. Even Niagara Falls has given way very materially in the course of fifty or a hundred years.

Mr. MORISON. Yes; but they are away above Lake Ontario.

The CHAIRMAN. They have receded, nevertheless, and changed in their appearance.

Mr. MORISON. Yes; but they are above the water. This valley is below.

Senator HARRIS. Mr. Morrison means that for erosion to take place there has got to be a fall. Of course, that is correct.

Mr. MORISON. What I mean by a geological valley is that a valley can be traced in the rock well below the present surface of the country; that that valley is filled up with material which is not rock, some of which is water-tight and some of which is not; and quite a lot of stuff in the very lowest portion of it is permeable to water—is not water-tight.

Senator HARRIS. I should like to have you state to the committee your opinion as to the comparative difficulty in the construction of this flight of locks; that is, the locks with a maximum lift of 45 feet, each being right together. That is what the Commission means when it speaks of a flight of locks.

Mr. MORISON. Yes. You pass from one lock directly into the other.

Senator HARRIS. As regards any locks that you know of, now actually constructed, in their comparative height and difficulty of construction.

Mr. MORISON. Those locks are larger than any now in existence. I see nothing specially difficult about their construction.

Senator HARRIS. Does not the fact that two locks are right together, that you go from one immediately into the other, make them somewhat more difficult than if they were separated?

Mr. MORISON. No, sir; I see no reason why it does. It is a perfectly common thing to build locks in flights. The old locks at Sault Ste. Marie were in a flight.

Senator HANNA. And on the Welland Canal also.

Senator HARRIS. I was thinking of the great height of the wall involved in this, and the depth of the gates.

Mr. MORISON. Well, it makes a big gate, but I see no serious objection to it. The upper gate of the upper lock is high enough to admit vessels when that lock is full. The lower gate of the upper lock is high enough to let vessels out when that lock is empty, and that is just the same that it would be if you let them out directly into the canal. The gates are no higher than they would be for single locks with the same lift. It simply makes a larger concentration of masonry in one place.

Senator HARRIS. With the extraordinary height, that is, a total lift there of 90 feet, the walls, of course, have to be adequate to that.

Mr. MORISON. Yes.

Senator HARRIS. Does that present any more danger from earthquake action than if they were lower?

Mr. MORISON. No; I do not think it does. It is possible to use locks of less lift. You can put in locks of only 28 feet lift, and put a third lock below.

Senator HARRIS. That would make a greater number of locks.

Mr. MORISON. Yes; there is a very good place below to put another lock. I think there are arguments in favor of doing it, but that is one of the questions which I should expect to come up when the canal is actually built. It takes a little more time if you have the other lock, and it was considered better to use those locks. There is a lock of about the same lift, a single lock on the Nicaragua route.

Senator HARRIS. Thirty-six feet and a half.

Mr. MORISON. I thought there was one, under extreme conditions, of about 41 feet.

Senator HARRIS. In the Nicaragua plan the dam at Conchuda presents no more difficulties, does it?

Mr. MORISON. I think it is more difficult to build than any dam that has ever been built. Everything about it, every detail, is within limits that have been met. I do not think any dam has ever been built which is as difficult to construct as that Conchuda dam.

Senator HARRIS. Except the dam at Bohio. Do you not think that would be more difficult to construct?

Mr. MORISON. That has not been built.

Senator HARRIS. I am speaking of its being in contemplation.

Mr. MORISON. With the plan which I should favor for the Bohio dam it would be extremely simple. I think that plan is more difficult than the Conchuda dam, but I think the Conchuda dam is more difficult

than any dam that has ever been built. The Bohio dam has not been built.

Senator HARRIS. By "that plan" do you mean the plan of the Commission?

Mr. MORISON. Yes.

Senator HARRIS. Dams have been built equally high as the one at Conchuda?

Mr. MORISON. Yes.

Senator HARRIS. And with foundations equally deep?

Mr. MORISON. Yes; but never where it was necessary to let the river run over the foundation while the dam was being built. In this case you have got to put a foundation down in a river that you can not divert.

The CHAIRMAN. That is the real difficulty at Conchuda.

Mr. MORISON. That and its magnitude. Generally dams with very deep foundations have been in positions where it was possible to lay bare the bottom of the river and put the whole dam in dry.

The CHAIRMAN. Is that more difficult than it was to put a caisson down at the Memphis bridge?

Mr. MORISON. I do not think it would be any more difficult to put down a single caisson than the caisson at the Memphis bridge, barring the difference in the surrounding conditions.

The CHAIRMAN. The Memphis bridge caisson was deeper in the river.

Mr. MORISON. Yes.

The CHAIRMAN. And there was a stronger body of water to resist.

Mr. MORISON. That does not amount to anything after your work gets started. One of our foundations at Memphis, the deepest one, we put in without any trouble whatever of any kind. In the second foundation, before we began sinking the caisson, when we first landed it on the bottom, we were caught by a flood, and for a day or two had a pretty tough time; but as soon as we got fairly started sinking all those difficulties were over.

Senator HARRIS. What is your idea of the general character of the work along the Nicaragua Canal? Does it present anywhere any very serious difficulties aside from the question of magnitude?

Mr. MORISON. I do not know that it does, except that I think that swampy country between Greytown and the San Juan River is going to be a very difficult country to work in. It is practically a continuous swamp.

Senator HARRIS. That is, about 12 miles.

Mr. MORISON. Oh, it is about 40 miles, practically.

Senator HARRIS. All of it.

Mr. MORISON. Yes.

Senator HARRIS. Hills and swamps together?

Mr. MORISON. The line strikes hills, but until it gets up into the last few miles it is more in swamps than in hills.

Senator HARRIS. The magnitude of the work there is not very great, but the difficulty, you think, is in the class of material to be handled.

Mr. MORISON. Well, I refer to working through that long swamp, with the conditions which attend it. It is a swamp throughout. There are no roads in it. You can not make any roads except by hauling in material to make them. There have never been any, and there is a good deal of timber in that swamp. How much of it is below the water I do not know. I do not think we have any idea; but there is, in my

mind, a very uncertain element as to how much timber you will find to interfere with your dredges while working in that swamp.

Senator HANNA. What is the bottom—ooze?

Mr. MORISON. All kinds of things; in some parts sand. A good deal of it is ooze—soft. It is perfectly natural that there should be a swamp in a country of such excessive rainfall.

Senator HARRIS. But did the French have any special difficulty in that piece of swamp just back of Colon?

Mr. MORISON. I think not. But that is a very different swamp from the one back of Greytown.

Senator HARRIS. The swamp at Greytown is greater in extent.

Senator HANNA. What is the difference?

Mr. MORISON. The swamp at Greytown is very much larger in area, and it has a much heavier growth of timber on it. The swamp back of Colon is more like a river bottom which is more or less overflowed.

Senator HARRIS. Well, aside from it being timbered, I suppose there would be no very great difficulty in its character?

Mr. MORISON. I should think there was. They look entirely different.

Senator HARRIS. In the construction of the harbor at Greytown, as compared with the construction of the additional harbor which is required at Colon, the estimates seem to be in favor of Greytown.

Mr. MORISON. Yes.

Senator HARRIS. Do you think there is any great difficulty in obtaining sufficient depth of water at Greytown?

Mr. MORISON. That whole coast is made entirely of sand. You have simply got to dig out your sand and protect it and keep it dredged. At Colon there is coral rock, and the increased cost of the harbor at Colon is due very largely to the fact that our estimates were made on a canal 35 feet deep, instead of 30, as has hitherto been talked of. The French plan provided a canal a little less than 30 feet deep. That is about the normal depth of the present harbor at Colon. In order to adapt that harbor to 35 feet you have got to make a channel. That channel can be deferred until the canal is finished, if desirable, because there are not many ships that can not go through a harbor 30 feet deep.

Senator HARRIS. But if you make a canal 35 feet deep you have got to make the entrance deep enough to enable ships to go up it.

Mr. MORISON. I say it could be deferred until the canal was opened. You can open the canal to most classes of service now before deepening that. It should be done, sooner or later.

Senator HARRIS. As a practical proposition, I should like to know whether you think that really there is a necessity for making the canal 35 feet deep?

Mr. MORISON. Yes; I do.

Senator HARRIS. You think it ought to be that deep?

Mr. MORISON. Yes, I do. I believe myself that the traffic through that canal will be done in the largest ships that are running anywhere in the world.

Senator HAWLEY. Through the Nicaragua Canal?

Mr. MORISON. Through the canal, whichever it is. It will all be long-distance trade, and long-distance lines find their greatest profit in large ships. A large ship can be run, in proportion to her cargo capacity, more cheaply than a small one. The trouble is it takes too long to load and unload it.

Senator HANNA. And then the item of fuel is a very important factor?

Mr. MORISON. Yes.

Senator HANNA. To carry fuel enough to complete the voyage?

Mr. MORISON. Yes.

Senator HARRIS. There is another question about which I should like to have your opinion. That is as to the necessity of double-chambered locks. Do you think the traffic will be so great as to require that for a great many years?

Mr. MORISON. No, sir; I do not. I think a one-chamber lock would accommodate all the business. I do not look to see more than ten ships a day going through that canal, five each way.

Senator HANNA. The duplicate lock could be built at any time.

Mr. MORISON. Yes.

Senator HARRIS. You could look forward to completing it afterward.

Mr. MORISON. But I consider that the second lock is needed as an element of insurance. You can not afford to have your canal blocked by an accident to one lock. If you knock down a gate, or anything goes wrong with a lock, your whole traffic is closed until it is repaired.

Senator HARRIS. Then it is simply a matter of reserve accommodation?

Mr. MORISON. If you have two locks, you can use one while you are repairing the other. That is the only reason that I can see for using double locks, but I think it is a sufficient reason.

The CHAIRMAN. I believe, Mr. Morison, that you were assigned as chairman of a subcommittee of three engineers to investigate the Panama route and the routes lying below or to the eastward.

Mr. MORISON. I was on two committees. One was for the Panama route, and of that I was not chairman. One was for the routes east of Panama. I was chairman of that committee.

The CHAIRMAN. You devoted your special attention to those routes.

Mr. MORISON. Yes.

Senator HAWLEY. Have you paid any attention to the Darien route?

Mr. MORISON. Yes; I have, a great deal.

The CHAIRMAN. He testified about that before you came in, Senator.

Senator HAWLEY. What does he think of it?

Mr. MORISON. Which route?

Senator HAWLEY. That one that calls for a 9-mile tunnel, the San Blas route.

Mr. MORISON. The San Blas route is the best that has ever been discovered on the Isthmus, until you get in 2 miles from the sea at each end.

Senator HAWLEY. At which end?

Mr. MORISON. At each end. It is more than 2 miles on the Pacific end. So far as length of line and convenience of approach and harbors are concerned it is the best line there is; but it involves a tunnel which I consider absolutely fatal to it.

Senator MILLARD. You feel that the tunnel is impracticable?

Mr. MORISON. Yes; and even if that tunnel were perfectly practicable, I consider that the objection to taking ships through a tunnel 4 or 5 miles long would exceed all possible benefits and advantages which that line might have.

Senator MILLARD. What are the objections?

Mr. MORISON. In the first place, the tunnel ties you up in your

dimensions. You can not enlarge the tunnel. When it is done you never can increase the size of your ships. It is the unit. Two ships can not meet in the tunnel. You have to send one ship through at a time. Perhaps you can follow it by another going in the same direction, but no ship can come through from the other direction until the tunnel is cleared. Then you have the question of ventilating that tunnel. You have your bad air coming out of your smokestacks and all that kind of thing while you are going through. You have a large water resistance in there. If anything happens to a ship in the tunnel it is going to be a very awkward thing to get it out. If anything should happen which would cause the ship to sink or ground in the tunnel it would be a very difficult thing to get her out at all. Here is a sketch showing the size of tunnel selected by the Commission and the steamer *Deutschland* going through it. You see her masts would have to be changed.

Senator HAWLEY. That is a cross section of the tunnel?

Mr. MORISON. Yes.

Senator MILLARD. This is supposed to be a ship passing through there?

Mr. MORISON. Yes.

Senator MILLARD. It would pretty well fill the tunnel?

Mr. MORISON. Yes. Now, if anything happened to the ship, how would you get hold of it to get her afloat?

Senator MILLARD. I do not know. That is what I am asking you about.

Mr. MORISON. I do not know.

Senator MILLARD. I have heard a good many people speak of this as a proper thing to do, as a great saver of money and distance.

Mr. MORISON. I do not think it would save any money, and it would involve risks which you would not have on the other routes.

Senator HANNA. In the cost of operation you would save money by a sea-level canal, would you not?

Mr. MORISON. Very little. It costs very little more to operate locks. The cost of operation of locks is very small. That would be a canal anyway 30 miles long, which is a canal all the way. One of the advantages of this present plan of the Commission, the plan for the Panama Canal, is that your canal is nowhere over about 20 miles long. You go barely 20 miles and you come to Lake Bohio, where there is good anchorage, where you can lie up if anything is wrong, where there is plenty of room for passing, and when you get to the other end of that lake it is only about a dozen miles then to the Pacific.

We will suppose two fleets of half a dozen ships each waiting at each end of the canal in the morning. They could start in, one from Panama and the other from Colon. They would meet in Lake Bohio, where there was plenty of room to pass, and each of them would go through the last lock by daylight and be able to go out into the other ocean; or, if they wanted to enter the canal in the afternoon, they would get up to Lake Bohio, and if they did not want to go through any portion of the narrow canal in the darkness they could anchor there and go down in the morning. I think to get through this canal 30 miles long with the tunnel would be quite as great as to go through the Panama Canal would be, every bit.

Senator MILLARD. Would it be practicable to carry a ship through that tunnel by electrical power?

Mr. MORISON. I suppose it might be done.

Senator MILLARD. I know it was suggested by an engineer.

Mr. MORISON. It would require very powerful machinery to do it.

Senator HARRIS. There is really no reason why that outside power should be used instead of the ship's own power, is there?

Mr. MORISON. Yes; there is in the tunnel. If you use an artificial outside power you do not fill your tunnel with smoke. That is the only reason; but the amount of power that it will take to go through the tunnel even at 4 miles an hour is very large. To take that ship through at 4 miles an hour would probably require 5,000 horsepower and more. It would be likely to take 10,000 horsepower.

Senator MILLARD. The length of this tunnel is about 5 miles, is it not?

Mr. MORISON. That depends entirely on how deep you make the open cut. In the various routes we considered I think the lengths of tunnel varied from a mile and a half to about 5 miles.

Senator HARRIS. That would require an open cut 400 feet deep?

Mr. MORISON. Yes; which is a hundred feet higher than people have generally considered expedient.

Senator HARRIS. What do you think of the feasibility of a sea-level canal at any time in the future at Panama?

Mr. MORISON. A sea-level canal is feasible now at Panama if you are willing to take twenty years to build it. It will be very much more difficult to enlarge a canal built there with locks to a sea-level standard than to build a new one.

Senator HARRIS. The location would be varied somewhat?

Mr. MORISON. There is another possible location at Panama which, if the lock canal were built on the present line, might possibly be available for a sea-level canal; but my impression is that it would be better to deepen the canal near the present location.

Senator HARRIS. A good deal has been said about curvature. The Commission made ample allowance for the difficulties of curvature on both lines. On the Nicaragua line, where there was supposed to be more curvature, their plan contemplates the possibility of a ship navigating the canal without any difficulty, and without the necessity of tugs in getting around curves, does it not?

Mr. MORISON. Yes; it contemplates that, and the curvature in the Commission's report is very much less than that of any previous commission's report. At the same time there is a great deal more curvature, very much sharper curvature, by the Nicaragua route than by the Panama route.

Senator HARRIS. Do you remember what is the curvature on the Manchester Canal—the shortest radius?

Mr. MORISON. I can not tell you, but it is pretty sharp.

Senator HARRIS. Less than 2,000 feet?

Mr. MORISON. I think it is about two thousand feet. They have a good deal of trouble in navigating the Manchester ship canal, which I think is principally due to want of draft.

Senator HARRIS. The canal, I believe, is of less width than is contemplated here.

Mr. MORISON. Yes; this canal is of very large dimensions. And there is a thing about the tunnel which I forgot to mention. That is 100 feet at the base, which is 50 feet narrower than we contemplated for the canal anywhere else in our estimates.

Senator HARRIS. The question of draft would be a very serious one in there owing to the constriction and the shallowness too.

Mr. MORISON. Yes; and the resistance, in taking a ship through there.

Senator HARRIS. Dragging the water.

Mr. MORISON. Yes; the water has got to get behind you, and one effect of carrying that water through a narrow space is going to be that the surface will sink, and instead of having 35 feet, you will probably have about $33\frac{1}{2}$, or something like that; perhaps not as much. This shows 40 feet at the center, but only at the center. It is proportioned for 35 feet.

Senator MILLARD. Your ships would all have to go one way at a time only.

Mr. MORISON. Yes; even little ones. I do not believe I should be willing to have any ship pass another in the canal.

Thereupon (at 11.50 o'clock a. m.), the committee took a recess until 2.30 p. m.

WASHINGTON, D. C.,
Wednesday, February 12, 1902.

The subcommittee met at 2.30 o'clock p. m.

Present: Senators Morgan (chairman), Hanna, Foster, Kittredge, and Harris.

ADDITIONAL STATEMENT OF MR. GEORGE S. MORISON.

Senator HANNA. You have stated that you are a member of the Isthmian Canal Commission.

Mr. MORISON. I have.

Senator HANNA. And that you have spent in that work about how long a time?

Mr. MORISON. Well, it is about two years and a half since I was appointed on that Commission, which has taken the major part of my time, either in work or thought, since I was appointed.

Senator HANNA. And of course you have made a very careful study of this question in all of its features, bearings, and results?

Mr. MORISON. I have endeavored to.

Senator HANNA. Taking into consideration all the information and bringing to your aid all of the experience of your life as an engineer, which route, in your judgment, is the best for this Government to establish as an isthmian canal, to be owned and operated by the United States?

Mr. MORISON. I think the Panama route is decidedly the best, and for a good many reasons.

Senator HANNA. If you care to, you can state the reasons.

Mr. MORISON. Well, in the first place, I think it is better simply as a matter of engineering construction. The construction of the Panama canal is work which is now practically visible; the country has been cleared and we can see what it is. It consists really of two or three classes of work only, of which, with my views as to how the rest of the work should be done, the Culebra cut is the only one of extraordinary

magnitude, the only one which would control the time of construction. That Culebra cut is undoubtedly the largest piece of earthwork ever attempted; it will require special machinery to carry it out economically. It is a piece of work that reminds me of what a teacher said to me when I was in Exeter, over forty years ago, that if he had five minutes in which to solve a problem he would spend three in deciding the best way to do it. I think if you spend two years in getting ready you will have the work done quicker than if you start in six months, and I think that with a thoroughly organized outfit that work can be done for a less price than the Commission has estimated.

Mr. HANNA. And in less time?

Mr. MORISON. Probably it can. It is a question of special machinery, but machinery which we know how to make. It is preeminently the kind of work which American contractors adapt themselves to doing. Then I consider that the question of water supply and the regulation of the summit level has been solved in a very satisfactory way. Beyond that, the question of the harbors, though perhaps not much less expensive, are much less complicated and involve many less doubtful features than the control of the harbors at Nicaraugua. Panama is now all that is needed. Colon is all that is needed for vessels drawing 26 feet and under for three hundred and sixty-two days of the year. It has to be deepened, and there has to be some method of allowing ships to run in under shelter during the two or three days when there is a northwest wind.

Senator HARRIS. That two or three days of northwest wind you intend to mean the storm intervals that occur occasionally throughout the year?

Mr. MORISON. They very seldom occur more than once or twice a year.

Senator HARRIS. You do not mean that there is any series of two or three days when there is a northwest wind?

Mr. MORISON. No, sir; but I mean that those winds come, and when they come, ships can not lie at the wharves. They have never been able to do so.

Senator HANNA. But that does not occur oftener than once or twice or three times a year.

Senator HARRIS. That is what I was getting at, that he meant the occurrence of those storms.

Mr. MORISON. In some years it may not occur and in some it may occur two or three times a year. The Pacific Mail steamers in old times used to run out and go to Porto Bello, where they were amply protected.

Senator KITTREDGE. How far is that from Colon?

Mr. MORISON. Fifteen or twenty miles. It is a little harbor that was the first Spanish port there.

In general, I feel that the estimates for the Panama work are liberal and it will probably be finished for the estimated sum. I do not believe the Nicaraugua route will. I think the percentage allowed, when you consider that it is an undeveloped country where nothing has ever been done and where knowledge is derived only from borings and surveys, and much preliminary work, which has been done at Panama, remains to be done at Nicaraugua. I think that instead of that adding a contingent allowance of 20 per cent, it would properly be about 30 per cent.

Senator HANNA. That would make a difference in the neighborhood of ten or fifteen million dollars?

Mr. MORISON. Yes, sir.

Senator HANNA. With the Panama canal completed, a ship can enter the canal by either end in the morning and pass the last lock and probably come into the ocean by dark?

Mr. MORISON. Yes; I consider that a very great advantage. Canals can be navigated by night, and I have no doubt they will be, but you want to avoid it if you possibly can, especially in one of those climates which is subject to serious rains. Lake Bohio makes an artificial lake in the middle of the canal which, when completed, will not be different from a natural lake, and it has all of the necessary space for anchorage and anything of that kind: a ship can lie there over night, or fleets that enter both ends in the morning can pass there.

Senator HANNA. How long is that lake?

Mr. MORISON. About thirteen miles; the wide portion of it is perhaps eight.

Senator HANNA. To a depth of water all over?

Mr. MORISON. The upper end is not deep enough for big ships to get out of the channel. At the lower end there is a great abundance; small ships could go some distance from the channel in the upper end.

Senator HARRIS. What is the greatest width of the deep water, if you remember?

Mr. MORISON. I can not tell you that, but it would be measured by miles.

Senator HANNA. The lake must extend very considerably—some distance above the dam?

Mr. MORISON. The lake fills not only the valley of the Chagres, but the valleys of the tributaries of the Chagres, and the greatest width would be where it filled up one of those side tributaries. It is a very irregular-shaped sheet of water.

Senator HANNA. There would be bays around the edge of the lake, with deep water?

The CHAIRMAN. Do you recollect how many tributaries there are into Lake Bohio?

Mr. MORISON. No, sir.

Senator HANNA. Is there more than one?

Mr. MORISON. Yes; every stream that runs into the lake is a tributary, and some of them are so small that they are insignificant, and there are several of size.

The CHAIRMAN. Can you name any one of the principal ones?

Mr. MORISON. The Gigante comes in from the south.

The CHAIRMAN. Does that go into the basin of the lake?

Mr. MORISON. Yes, sir.

The CHAIRMAN. And flows through and enters into the Chagres River?

Mr. MORISON. Yes, it does now flow into the Chagres River. When the work is done the Chagres River will flow up the course of the Gigante and discharge over the spillway.

The CHAIRMAN. And come out the other way?

Mr. MORISON. Yes. I can not recall names of the streams. There are several others.

The CHAIRMAN. Does that Gigante Creek enter into the Chagres, unite with the Chagres, above the Bohio Dam?

Mr. MORISON. Yes, it does.

The CHAIRMAN. How far above?

Mr. MORISON. About 2 miles.

The CHAIRMAN. It is a little bit of a rivulet, is it not?

Mr. MORISON. It is not a very large stream, but a good deal of water must come down it in the wet seasons. There is enough water entering Lake Bohio between Obispo, where the canal leaves it, and Bohio, where the dam would be, to make the discharge of the Chagres at Bohio from one-third to one-half more than it is at Obispo. In other words, the flow of the streams which enter the Chagres in the limits of the lake would be something like one-half the flow of the whole river where it enters the lake from above.

Senator HANNA. You spoke this morning about the Bohio Dam, and it is not necessary to repeat, but testimony has been given here that the silt from the Chagres River would, within probably a space of twenty years, fill up that dam.

Mr. MORISON. I do not think there is any possibility of that. The Chagres River rises in the mountains where there are no signs of any silt. The banks of the river above the site of the Alhajuela Dam are rocky, with some very coarse gravel, like a mountain stream which carries no silt. Below that point you find the first signs of silt. There is silt in the banks of the river 10 miles below Alhajuela, and from there down it increases. So long as the river runs as it does now it will wash those silt banks and carry them down and move about more or less silt; that is, in times of high water. If, however, you build a dam across that river and convert it into a lake, you stop the current that washes the silt, and that silt remains practically undisturbed in the bottom of the lake, and the only silt brought into the lake will be the infinitesimal amount which is brought by the mountain stream above those limits. That is one reason why I prefer the Commission's plan, which puts the level at 85 feet, rather than a lower one, because it will flood the valley of the Chagres up to the upper limits of any silt banks.

The CHAIRMAN. What would the distance be from the present dam site?

Mr. MORISON. Something over 20 miles.

Senator HANNA. Slack water?

Mr. MORISON. Yes, sir.

Senator HANNA. When the dam is finished?

Mr. MORISON. Yes; but the upper 7 are not in the line of the canal; it is an extension where steamboats—little boats—can go for bananas or something of that kind, but it will not be on the route of deep-water navigation.

Senator HANNA. Then in your judgment that danger of filling up the lake from deposits from the river would be little?

Mr. MORISON. I do not consider that it amounts to anything. That is one of the functions of lakes; they are settling basins. You never find a river that runs out of a lake which carries with it much silt.

Senator KITTREDGE. What about the cost of the maintenance and operation of the Panama Canal as compared with the other?

Mr. MORISON. Our Commission made an estimate by figuring out the number of dredges that would probably be needed and the force of men probably required, and it came to \$2,000,000 for the Panama Canal and about \$3,300,000 for Nicaragua. Each canal has got to keep a certain staff independent of that which actually handles the

material. I think that probably that is as fair an estimate as can be made.

Senator HANNA. Testimony has been given here by a naval officer who is not an engineer, but who had been on the isthmus on a pleasure trip, I believe, to the effect that there were 3 or 4 miles or 5 miles of the bed of the canal where, at a depth of about 8 feet from the surface, they had struck a volcanic formation of rock, spongy and porous, upon which the explosion of dynamite had no effect, and that in order to deepen that to the required depth of 35 feet for the canal they would have to build a cofferdam and pump the water out, and then cut that material out with some machinery, the same as you would cut anything that could be cut by steel. Do you know of any such place?

Mr. MORISON. I don't know of any such place. Around Colon Harbor the bottom rock is a coral rock, which is—I am not sure but what it would be a bad rock to blast. On the other hand, it would be a comparatively easy rock to work in other ways.

That class of material is found wherever you have lava; that is, you are liable to have a porous lava. There is a great deal of it in Arizona, in which powder seems to find a side vent through fissures. There may be some at Panama, although I do not know of it.

Senator HANNA. If there had been conditions such as I have described, which would cause the engineers in charge to abandon the work until such time as they could construct a cofferdam, you probably would have heard of it?

Mr. MORISON. I think so. I think that class of material is much more likely to be found in Nicaragua than in Panama, for the reason that the Nicaragua country contains a great deal more signs of volcanic activity, and that class of rock is such as comes from recent volcanos.

Senator HANNA. With reference to Culebra cut, you have stated this morning that it is only a question of magnitude, and not of physical or engineering difficulty, and you now say that with modern machinery you think that work could be carried on more rapidly than it has been up to the present time. What have you to say with reference to the drainage of that cut? Is that provided for? I understand this material through which that cut is made is hard clay, almost approaching the tenacity of rock, but that it washes or dissolves in water or in contact with water.

Mr. MORISON. I do not think that amounts to anything. It is a clay; it is a hard clay; it does weather; it would weather very rapidly in a northern climate where we have frost. In that climate it weathers, but I think it will weather very slowly. The appearance of the slopes of the cut as far as it has been taken out indicates this. The only thing that gives any doubt of the stability of that material is that if you take a small piece of it and drop it into a glass of water it very soon falls into a powder, and that is a very curious thing. I picked out a piece of that stuff myself from a point 60 feet below their excavations. I went down in a bucket into a test pit. That pit had been full of water for a year, and they had just pumped it out, and I took out a piece of clay and it seemed to be in fair condition. I brought it to Colon and put it in water and it fell to pieces just as the others did. Now, that our estimates have provided for. We have provided for a heavy retaining wall the entire length of that Culebra cut on each side.

Senator HARRIS. That is on each side of the canal, and not of the cut.

Mr. MORISON. No, sir; not of the cut. The greater portion of it is under water. We have estimated more than \$9,000,000 for that wall. There are the exact figures [referring to a table], those two added, before the 20 per cent is put on. This is one of the things that make me feel that our estimate for the Panama route is much more liberal than our estimate for Nicaragua, for if we had had only borings of the cut, and had not seen the actual material in it, we should never have thought of putting it in.

Senator HANNA. From any superficial examination?

Mr. MORISON. Yes, sir.

The CHAIRMAN. How far below the bottom of the canal does that wall go?

Mr. MORISON. Only about 3 feet below the bottom of the canal. It reaches from the bottom of the canal about 5 feet above the highest water in the canal.

The CHAIRMAN. That is to say, it reaches from 3 feet below the bottom of the canal up to the distance you stated above high water?

Mr. MORISON. Yes; and then the slopes are estimated on the basis that they come down to the bottom of the canal. Now, that leaves a bench 50 feet wide on each side, on the level at the top of that wall, so that any material that may fall down from the slope has a bench 50 feet wide to land on.

Senator HARRIS. Is it not 35 feet? That was mentioned as the basis of that berme.

Mr. MORISON. It is possible that I am wrong. One of our plans was 50 feet. It probably would be 50 feet actually, because we should probably not take out the canal with a flat slope, but with a series of benches—steeper intermediate slopes.

Senator HARRIS. The general slope, I believe, is considered to be one to one.

Mr. MORISON. It is estimated as exactly one to one, terminating at the bottom of the canal.

Senator HARRIS. Do you think that clay, with the rainfall and its inclination to disintegrate, is safe at a slope of one to one?

Mr. MORISON. Yes; I think if the cut was only 50 feet deep, it would be safe almost vertical.

Senator HARRIS. Here the practice ordinarily in earth cuts, railroad cuts, it is about one and one-half to one.

Mr. MORISON. That depends on the quality of the soil. It is generally one to one. In many parts of the West it is one-half to one, and in many parts of the South it is as low as one-quarter to one. But here you have the worst possible conditions, because we have a maximum amount of freezing and thawing.

Senator HANNA. In the north, you mean?

Mr. MORISON. We have it worst right here in Washington.

Senator HANNA. I mean in this latitude. You have made no provision for surface water, keeping it out of the cut?

Mr. MORISON. That does not require any particular estimate. It is simply a matter of care in depositing the spoil banks. They have to be so deposited that they do not hold water behind them. That has not always been done in the French management, but it can be done.

The CHAIRMAN. Do those slopes in the Culebra and the Emperador cuts readily cover themselves with vegetation?

Mr. MORISON. They have not much. It seems to be a very hard material—too hard for vegetation to grow on readily.

Senator HANNA. From the cut west to the Pacific Ocean are there any physical conditions there that need special attention?

Mr. MORISON. Nothing unusual. There is a long channel out into Panama Bay. It is somewhat the same class of work as in Mobile Bay, only it is not so long; it is not more than a quarter as long.

The CHAIRMAN. There is no coral in Mobile Bay?

Mr. MORISON. There is no coral in Panama Bay. It is at Colon that the coral is found. There is coral in the approach to the bay, but not where the harbor channel is. There is coral between La Boca and the first lock, but not where the harbor channel is.

Senator HANNA. That is in the shore?

Mr. MORISON. Yes, sir.

Senator HANNA. But not out to sea?

Mr. MORISON. No, sir. The steamers that now enter Panama Bay are perfectly willing to ground.

Senator HANNA. But they anchor out 4 miles?

Mr. MORISON. Well, this channel would be in the same kind of a region.

Senator HARRIS. But under the coating of mud there still might be coral. It has been testified that this excavation will require considerable excavation of coral.

Mr. MORISON. There is some excavation of coral rock inside of low-water shore line in Panama Bay. I don't think there is anything outside.

Senator HANNA. I think it was Mr. Haupt that gave that information to the committee. Was he there with you?

Mr. MORISON. No; he did not go to the Isthmus with the Commission. He had been down there before, but he did not go with the Commission.

Senator HANNA. Had he been there as a member of a former Commission?

Mr. MORISON. He had been there as a member of the Nicaragua Commission. He had been to Nicaragua, and they also went to Panama.

Senator HANNA. Why did they go to Panama?

Mr. MORISON. I was not a member of the Commission and I do not know.

The CHAIRMAN. That is the Commission of which Admiral Walker was the president?

Mr. MORISON. Yes; they spent some time in Nicaragua and returned by way of Colon, and while there they went over the route of the canal.

Senator HANNA. But Mr. Haupt was not on the Isthmus at either the Panama or the Nicaragua line in the last Commission?

Mr. MORISON. No, sir. The channel now from deep water in to the mouth of the canal at La Boca is deep enough to take any ship that would ever want to use the canal at high water. It is not deep enough to do it at low water.

Senator HANNA. At mean tide how would it be?

Mr. MORISON. At mean tide I think it might do, although the channel is not quite what would be wanted for mean tide. In fact, in my judgment, it would be an unwise expenditure to deepen that channel to 35 feet below low water, but that is the estimate of the Commission. That will give 45 feet at mean tide and 55 feet at high tide. Those are conditions which have never been made at any ports that I know of anywhere in the world where they have that range of tide. They consider it justifiable to take advantage of the tide to get in. Now

ships can enter Liverpool Harbor, that is, they can go over the mouth of the Mersey at low water, but they can not dock without about two-thirds tide.

Senator HANNA. With reference to the curvatures on the Panama route, testimony has been given here that there is one curve in the harbor of Colon which is at a sharper angle than that of any other on either route. Do you consider that as proposed to be constructed, with 500 or 600 or 800 feet wide at the bottom, that it is any disadvantage in the operation of vessels?

Mr. MORISON. A vessel must go slow to go around it. That curve comes at just the place where any ship entering the canal will have to stop to be entered and pay her tolls and other things of that kind. She will probably stop before she goes around that curve and have something to help her around it.

Senator HANNA. Then from that until she enters the Pacific the curvature is very easy?

Mr. MORISON. Yes; it is easier than in any canal of importance in the world.

Senator HANNA. Easier than any in the world?

Mr. MORISON. I think so. The matter of a curve is a very different thing according to its location. On the Suez Canal they formerly had, and I think they still have, an extremely sharp curve.

Senator HARRIS. When you speak of the Panama being less than any other in the world, are not all of the curves, both on the Nicaragua and the others, easier than any other canal?

Mr. MORISON. I do not want to say that the Nicaragua is not; I can not say that it is. At a place on the Suez Canal the canal forms a sort of fan in this way, and a ship will come in here and then she would have that bay to back around into and then go on. It would be a very simple thing to change this curve that we are speaking of at Colon into a large triangular space. Probably that would be done.

Senator HANNA. By cutting off the point?

Mr. MORISON. Not by cutting off the point, but by cutting opposite the point. If you will give me a pencil and a piece of paper I will show you what it is. [Drawing diagram on paper.] Here is the outer bank, and the canal comes in here. This is widened out for a broad canal. Here is the harbor out here, and here is a place where the statue of Columbus stands. One reason for getting around there quick is that if you come around there this point at once becomes a shelter; but if you were to take cut corner out there a ship could come up here, pull up along there, and then whenever she is ready to go a tug could very quickly pull her bow around there and she would go right off. I do not think that is to be counted as a curvature in the canal.

Senator HANNA. Quite a feature has been made of the sanitary conditions along the route of the Panama Canal—that owing to the climate and other things there is a great deal of mortality. At the time you were there what were the conditions as compared with former years?

Mr. MORISON. We were there not a great while. There was yellow fever there when we were there. I do not think there was a great deal.

Senator HANNA. I mean as applied more particularly to the working force along the whole route.

Mr. MORISON. I don't think there was much sickness among the men along the whole district.

Senator HANNA. In the early days there was a great deal.

Mr. MORISON. I think the diseases at Panama are very largely due to artificial conditions. The Isthmus of Panama has always been an unhealthy place. It has been inhabited for four hundred years, and I think you may say that there is not a water pipe or a sewer on the whole Isthmus. The city of Panama has never had so bad a reputation for sickness as Santiago de Cuba, and we know what has been done at Santiago de Cuba. I think that we know now how to handle sanitary conditions at Panama.

Senator HANNA. Well, that is in the city of Panama; but the evidence was furnished here that out of a working force of 400 men—I have forgotten now the length of time they were at work—when they left there only 10 ever reached this country alive.

Mr. MORISON. Well?

Senator HANNA. About 400 were taken out there, and they all died off but about 20 or 30, and most of them died before they got back.

Mr. MORISON. Well, that is perfectly possible in time of yellow-fever epidemic. The first thing to do on the Isthmus is to get a supply of good water. There is plenty of good water on the Isthmus, but the people do not have it; and the next thing is to dispose of their sewerage. With those two conditions met, three-fourths of the sickness on the Isthmus will disappear.

Senator HANNA. The French company had studied all those conditions before they made any preparations to avoid these troubles.

Mr. MORISON. I can not say that they have studied them very much. You see they abandoned their work there ten years ago, and the advance in sanitary matters in the last ten years has exceeded what it was in the previous fifty years.

Senator HARRIS. It will be necessary not only to take care of the health of the employees right along the line, but the health of the city of Panama itself has to be looked after.

Mr. MORISON. Certainly; that is absolutely necessary.

Senator HARRIS. It becomes a radiating center of disease otherwise?

Mr. MORISON. The city of Panama must be treated in the same way as Habana. The whole Isthmus must be treated in that way.

Senator HANNA. In a malarial country like that, is it not true that a good deal of sickness in the nature of fevers comes from the breaking up and disturbing of primitive soil?

Mr. MORISON. That has always been the theory, and I think that it is probably correct. The Panama Railroad Company makes it a rule with their white employees to give them two months' furlough every year—one month at full pay and one month without pay—and to give them transportation between New York and Colon back and forth, they paying their own board on the ship. With that provision they do not seem to have any special difficulty with the health of their men.

Senator HARRIS. The Commission make no estimate whatever as to the sanitation of Panama and Colon?

Mr. MORISON. Not in detail. That is one of the things which is included in the 20 per cent, and it is my own judgment that the sanitation of the Isthmus of Panama involves much less untried work than the sanitation of the swamps of Nicaragua. In fact, our experience in Cuba has been of enormous value in showing what could be done at Panama. I can not say that it has been of value in teaching us how to handle swamps.

Senator HARRIS. Well, swamps will not produce yellow fever.

Mr. MORISON. If the last reports are correct, we can get rid of yellow fever by killing the mosquitoes. The swamps will produce fevers that are worse than yellow fever.

Senator HANNA. Then, summing up the proposition of the Panama Canal route, there are to your mind no physical difficulties that are insurmountable or approaching that, and no engineering difficulties but what can be easily overcome?

Mr. MORISON. Well, which it is perfectly practical to overcome.

Senator HANNA. That is better. In view of those facts, do you consider the price at which this property is offered to us a reasonable price?

Mr. MORISON. Yes; I do.

Senator HANNA. Do you consider it a low price?

Mr. MORISON. I consider it a very fair price. That price represents, as near as we could estimate it, what would have to be expended now, if nothing had been done in the Isthmus, to put the Isthmus in such condition that the cost of the completing of the canal would be what it is now.

Senator HANNA. When that proposition was made by the new company I understand that it did not embrace a great deal of machinery, in the way of locomotives and other machinery there, that has since been added to the scrap pile which we buy.

Mr. MORISON. Yes. I would not give anything for any of the machinery down there.

Senator HANNA. Because you could get better?

Mr. MORISON. Because it is twenty years old. You can not afford to use it. The locomotives are too small; they have not more than half the power they ought to have, and there are a great many machines there that nobody has ever discovered the use of.

Senator HANNA. You say that Mr. Haupt was not on the Isthmus. What work was assigned to him as his work on the Commission?

Mr. MORISON. He was a member of what we call the committee on value of the canal. He attended all of the meetings, or nearly all of them, when they were held in Washington, and followed up a good many subjects, but I do not know why he did not go to the Isthmus.

Senator HANNA. Have you ever been over the route of the Nicaragua Canal?

Mr. MORISON. Yes; the whole of it.

Senator HANNA. How long a time did you spend?

Mr. MORISON. I went with the Commission. We were about a month going over it.

The CHAIRMAN. Did you go through those swamps that we have been talking about?

Mr. MORISON. Yes; I did not go through, but went into them and saw a good deal of them. Men who were on the lines went through them. You can only go through them in boats, and by occasionally wading.

The CHAIRMAN. Did the engineers have boats?

Mr. MORISON. Yes; nobody could go through those swamps in any other way.

The CHAIRMAN. How many lines have been run through there?

Mr. MORISON. I could not tell you.

The CHAIRMAN. Quite a number?

Mr. MORISON. Yes; some of them were run by the present Commission and some by the preceding Commission.

The CHAIRMAN. Well, beginning as far back as Childs's lines upon lines that have been run through there?

Mr. MORISON. Yes; Colonel Childs was the first man to make a good survey of the Nicaragua route, and I believe that at the time Mr. Childs made that survey the Nicaragua route was probably the best route. At that time he made the statement, I think, that there were only 15 ships in existence that drew 17 feet, and his plans were made for a canal 17 feet deep. He then made a further estimate for a canal 12 feet deep. What he proposed was a system of slack-water navigation of the San Juan River which was very attractive.

The CHAIRMAN. That was a dam at every rapid?

Mr. MORISON. A dam which would submerge every rapid. That made the canal a very attractive thing, for if you improve the navigation of the San Juan a vessel could go up the river and across the lake to within about 12 miles of the Pacific. It seemed as if all that had to be done was to build a canal about 17 miles long to connect the lake with the Pacific.

The dams which would make slack-water navigation would have to be founded on sand for the lower half of the river. The river is 100 miles long, and it is 100 feet higher at one end than it is at the other. That tells the story to an engineer. No river can fall a foot in a mile without having a great many obstructions, and in the lower half of that river, below the San Carlos, these obstructions are all sand bars. It was Colonel Childs's scheme to put in a series of low dams and a series of locks of low lift, and in that way get slack-water navigation—the same thing that had been in many of the rivers of this country, though it is nearly all abandoned now.

The CHAIRMAN. He ran his line into Greytown?

Mr. MORISON. Yes, sir.

The CHAIRMAN. He did not run it out to the mouth of the San Carlos?

Mr. MORISON. At that time the largest channel of the San Juan was the one that bears that name. The Colorado is the largest now.

The CHAIRMAN. Did he channelize at all except on the other side of the lake? Did he have any actual canals dug?

Mr. MORISON. Yes; there was a canal under his plan through the low country.

The CHAIRMAN. Through these very bottoms that you are talking about now?

Mr. MORISON. Yes, sir.

The CHAIRMAN. How long was that?

Mr. MORISON. I can not tell you; it is in the report.

The CHAIRMAN. Was it not as much as 18 miles?

Mr. MORISON. It may have been.

The CHAIRMAN. That was a practicable canal for ships of that size?

Mr. MORISON. I think so.

The CHAIRMAN. Could you put such a canal as that between Panama and Colon, across the Culebra Hills and keep it supplied with water?

Mr. MORISON. Well, it would depend upon how high you went up. I do not know that you could unless you pumped the water. You could not have gone up any great height without pumping your water.

The CHAIRMAN. That is what I mean.

Mr. MORISON. And that was a sufficient reason for adopting Nicar-

agua at that time, but with the increased draft of ships and the increased depth required in a canal the whole thing was changed. I think the first confession of that came from Mr. Menocal, when he decided to abandon the Lower San Juan entirely, to build a dam at Ochoa, and to extend the level of Lake Nicaragua into a side basin until he got pretty near to the sea.

The CHAIRMAN. He would save about 13 miles on the lines that he laid down.

Mr. MORISON. Yes; his line would be an ideal line if it could be built.

The CHAIRMAN. That was not a confession, but it was the adoption of a shorter line.

Mr. MORGAN. I think it was a confession that he could not improve the San Juan River, that you have got to abandon the San Juan River instead of following it down.

The CHAIRMAN. Do you remember any statement of Mr. Menocal to the effect that he could not carry the canal through?

Mr. MORISON. No; I do not know that he made one.

The CHAIRMAN. When he makes a statement to the reverse, you would not consider that he had confessed that he could not do it?

Mr. MORISON. It depends upon what meaning you take. He certainly considered that the other thing was better.

The CHAIRMAN. There is no doubt about that.

Senator HANNA. Was that the line adopted by what was known as the Maritime Canal Company?

Mr. MORISON. Yes; the difficulties of that were extreme. Their dam across the San Juan was at Ochoa; the Ochoa Dam had to be founded in sand, and had to be founded in the current of the river, for there was no means of diverting the river anywhere else. Furthermore, the dam was not the whole difficulty; the summit level had to be maintained by a long series of embankments. Each successive examination has led to an improvement in the line between the San Juan River and the sea. I think the line adopted by the present Commission is very decidedly better than any of the others, but when it is done it involves a continuous canal from the ocean at Greytown to the entrance of the San Juan.

The CHAIRMAN. To Conchuda?

Mr. MORISON. Yes; to the San Juan above Conchuda, which is as long as the entire Panama Canal and is a canal all the way without any relief from lakes or anything of that kind; it is a canal for the whole distance.

The CHAIRMAN. That is the canal that you have adopted?

Mr. MORISON. Yes.

The CHAIRMAN. And recommended to the Government?

Mr. MORISON. That is the one that we considered the best location in Nicaragua.

The CHAIRMAN. I am not asking what Mr. Menocal's judgment was, or his hopes for the future. You considered his routes impracticable from an engineering standpoint?

Mr. MORISON. Yes; both from an engineering standpoint and a military standpoint, because it could be very easily destroyed.

There is one thing that I have never seen mentioned. It may amount to something and it may not. A ship could enter the Nicaragua canal at Brito, and after it had entered it a foreign fleet could sail from the dockyard at Kingston and reach the Greytown end of the

canal before that ship got through the canal. It could not do it at Panama.

The CHAIRMAN. If that is so, having a foreign vessel hostile to the United States, if one was to enter upon the Pacific side of that canal could not a ship sail from Key West or Habana before the ship could get through?

Mr. MORISON. No, sir.

The CHAIRMAN. What would be the difference in the distance?

Mr. MORISON. You can not do it. We can just do it from Kingston, Jamaica. Jamaica is pretty well situated to get at the Isthmus.

Senator HANNA. The Commission in their report state that the cost of operation and maintenance, respectively, of the two routes in Nicaragua and Panama is in Nicaragua \$1,300,000 more than at Panama. Is that your judgment?

Mr. MORISON. Yes.

Senator HANNA. That is the interest on \$65,000,000, Government rate?

The CHAIRMAN. What was Mr. Childs's estimate of the cost of his canal?

Mr. MORISON. I should have to look that up.

The CHAIRMAN. It was about \$25,000,000, was it not?

Mr. MORISON. I think it is all in our report. I would rather refer to that report than to give it without reference.

Senator HANNA. How do you regard the dangers of navigation, which would have to be covered by insurance, between the two routes?

Mr. MORISON. I think they would be about in proportion to the length of the route; that is the additional premium to be paid over what it would be if it was the same distance of deep-sea sailing.

Senator HANNA. Mr. Haupt made a calculation, which was interesting to say the least, to overcome that difference in the cost of operation, which would reduce it to \$900,000 as compared with your \$1,300,000, the time to be saved from ports of New York, or from a port on the Atlantic, to ports on the Pacific, to San Francisco, of one day, and from ports on the Gulf of Mexico to San Francisco, two days. He stated that the saving of time and expense to a vessel would overcome the difference in the cost of the operation of the canal. I want to bring out the fact that he placed the cost of operation between the two routes \$400,000 less than the Commission did. Do you know whether that part of the work was assigned to him?

Mr. MORISON. That part of the work was assigned to a special committee, consisting of General Ernst, Mr. Noble, and myself, and the work was done very largely by General Ernst.

The CHAIRMAN. You mean the estimates of maintenance?

Mr. MORISON. Yes.

The CHAIRMAN. I would be very glad if you can give the items of maintenance on both routes.

Mr. MORISON. Well, it is a long matter, and I have not the figures of it here. I could furnish you with a copy of the draft.

The CHAIRMAN. I would be glad to get it.

Mr. MORISON. I understand that General Ernst is to appear before this committee, and as he was the man who did the greater part of that work, I should a little rather have it furnished by him than by myself.

The CHAIRMAN. Well, I will get it from him. I want to get it in the record if I can. I have never seen it.

Mr. MORISON. Each member of the committee has it and I think very likely each member of the Commission. The greatest advantage of the Nicaragua Canal—I think I may say that it is the only advantage it has—is that its west end is 500 miles nearer San Francisco than the west end of the Panama Canal. That means that a slow steamer, the class that usually carry freight, running night and day through the Nicaragua Canal, would get to San Francisco in one day less time than she would if she went through the Panama Canal. If, however, she did not run day and night, but tied up during the night, running only during the day, she would get to San Francisco in the same time by both routes.

The CHAIRMAN. You spoke of the Suez Canal. Is not that navigated at night?

Mr. MORISON. Yes.

The CHAIRMAN. How do they manage to do it?

Mr. MORISON. You can navigate canals at night. If you will let me finish my answer I will take up this subject afterwards. If, however, you consider very high-powered ships, a fast modern ship would get to San Francisco just as quick through one route as through the other; and she would get there a day quicker by way of Panama than she would if she laid up nights on the Nicaragua route.

Now, Mr. Chairman, the Suez Canal is carefully lighted, and no ships are allowed to run at night unless they have a particular system of electric lights.

The CHAIRMAN. The ship itself?

Mr. MORISON. The ship itself. Furthermore, you probably can not find a more perfect climate in which to run at night. That is the climate of the Suez; it is the climate of Egypt, which we all know is practically a rainless climate and the nights are very clear; further, it is a canal with soft banks, and if a steamer strikes the banks it does not hurt her.

Senator HANNA. With reference to the general saving of time in the commerce of the world, ships coming from Europe, any port of Europe, the Mediterranean, or anywhere else, and going to Australia, or the west coast of South America, would there be any advantage in the Nicaragua over the Panama route?

Mr. MORISON. Some time ago I tried to study that matter up myself, and if you will permit me I will read you this paper which I have prepared.

Senator HANNA. We should be very glad to have you do it.

Mr. MORISON. I want it distinctly understood that all of these estimates are based upon the assumption that the ship while going through the Nicaragua Canal runs day and night. The paper is as follows:

"New York may be taken as the representative of all North American Atlantic ports; the course from all these ports to either Colon or Greytown would be around Cape Maysi, the eastern end of Cuba.

"New Orleans may be taken as the representative Gulf port, the course from there to either Panama or Greytown being through the Yucatan Channel.

"Plymouth, England, may be taken as the representative of all European ports, and it may be assumed that the course from any European port to either Colon or Greytown would be by way of St. Thomas, stopping there for coal. If another coaling station is used it will make no very material difference.

"The distances from these several ports to Colon and Greytown are as follows:

TABLE I.

Port.	To—		Difference in favor of Colon.
	Colon.	Grey-town.	
New York.....	Miles. 1,965	Miles. 2,025	Miles. 60
New Orleans.....	1,400	1,260	-140
Plymouth.....	4,495	4,665	170
Average.....			30

"The distance from New York is calculated from Sandy Hook. Gibraltar, which would represent all Mediterranean ports, is 222 miles nearer St. Thomas than Plymouth is, but the difference will be constant.

"The time required to pass through the Panama Canal is approximately equal to the time required for a steamer to travel 150 miles at sea. The time required to pass through the Nicaragua Canal is approximately equal to the time required for a steamer to travel 400 miles at sea. These distances correspond to a speed of 12 miles an hour at sea; they represent an advantage of 250 miles in favor of Panama; with a speed of 10 miles per hour this difference would be reduced to 208 miles; with a speed of 15 miles per hour it would be increased to 312 miles; to avoid unnecessary complications they are considered a fair mean for all conditions. If we add these distances to those given above we have the practical distances from the three representative ports to the Pacific termini of the two canals, as follows:

TABLE II.

Port.	To—		Difference in favor of Panama.
	Panama	Brito.	
New York.....	Miles. 2,115	Miles. 2,424	Miles. 310
New Orleans.....	1,550	1,660	110
Plymouth.....	4,645	5,065	420
Average.....			280

"In general it may be said that it will take about a day longer in the average of all voyages for steamers to reach the western terminus of the Nicaragua Canal than to reach the western terminus of the Panama Canal.

"On the Pacific there will be three classes of traffic; that going to San Francisco and all Northern Pacific ports, including those of Asia; that going to South American ports; that going to South Pacific ports, as in New Zealand and Australia.

"Yokohama may be considered the first port that will be made by steamers going to either Japan or China. In order to make a coaling point voyages would be made either by way of San Francisco or of Honolulu. Of these routes that by way of San Francisco is 1,500 miles the shorter. For these reasons the port of San Francisco may be considered as representing not only California traffic, but all traffic for China and Japan.

"Manila, which may be taken as the representative port of the Philippines, is 200 miles farther from Brito by way of Honolulu than by way of San Francisco, and 186 miles farther from Panama by way of Honolulu than by way of San Francisco. The relative difference is really very slight, and the two routes may be considered as practically of equal length.

"San Francisco is 3,179 miles from Panama and 2,636 miles from Brito, a difference of 543 miles in favor of Brito. Combining these distances with those given in Table II, we have the through distances to San Francisco by way of the two canals, as follows:

TABLE III.

	Via Panama. <i>Miles.</i>	Via Nicaragua. <i>Miles.</i>	Difference in favor of Nicaragua. <i>Miles.</i>
San Francisco from—			
New York.....	5,294	5,061	233
New Orleans	4,729	4,296	433
Plymouth	7,824	7,701	123
Average.....			263

"On San Francisco business it may be said that the Nicaragua route has an advantage in time from sixteen to twenty-four hours.

"Another possible route across the Pacific is by way of Honolulu. Although this is a longer route to all trans-Pacific points, special local considerations will lead some vessels to take it. Honolulu is 4,681 miles from Panama and 4,150 miles from Brito, a difference of 531 miles in favor of Brito. Combining these distances with those given in Table II, we have the through distances to Honolulu by way of the two canals, as follows:

TABLE IV.

	Via Panama. <i>Miles.</i>	Via Nicaragua. <i>Miles.</i>	Differ- ence in favor of Nica- ragua. <i>Miles.</i>
Honolulu from—			
New York	6,796	6,575	221
New Orleans	6,231	5,810	421
Plymouth	9,326	9,215	111
Average			251

"There is practically no difference in the relative distances by the two canals whether the route to Asia be taken by San Francisco or by Honolulu. The fact that Honolulu lies almost exactly half way between the Isthmus and Manila indicates that this may be a favorite route to the Philippines in spite of its slightly greater length.

"The greater part of the traffic with the west coast of South America will pass around Cape Blanco, which may be taken as a governing point for all this traffic. Cape Blanco is 813 miles from Panama and 975 miles from Nicaragua, a difference of 162 miles in favor of Panama. Combining these distances with those given in Table II,

we have the through distances to Cape Blanco by way of the two canals as follows:

TABLE V.

	Via Panama.	Via Nica- ragua.	Differ- ence in favor of Panama.
Cape Blanco from—			
New York	Miles. 2,928	Miles. 3,400	Miles. 472
New Orleans	2,363	2,635	272
Plymouth	5,462	6,040	582
Average			442

"On west coast South American business, it may be said that the Panama route has an advantage in time of from twenty-eight to forty-two hours.

"The only other distances which it is expedient to consider are those to New Zealand and Australia. Wellington is selected as the New Zealand port and Sidney as the Australian port, this being the most westerly important port of that island. Wellington is 6,485 miles from Panama and 6,280 miles from Brito, a difference of 205 miles in favor of Brito. Combining these distances with those given in Table II, we have the through distances to Wellington by way of the two canals as follows:

TABLE VI.

	Via Panama.	Via Nica- gu-a.	Differ- ence in favor of Panama.
Wellington from—			
New York	Miles. 8,600	Miles. 8,705	Miles. 105
New Orleans	8,035	7,940	-95
Plymouth	11,130	11,345	215
Average			75

"Sidney is 7,669 miles from Panama and 7,410 miles from Brito, a difference of 259 miles in favor of Brito. Combining these distances with those given in Table II, we have the through distances to Sidney by way of the two canals as follows:

TABLE VII.

	Via Panama.	Via Nica- gu-a.	Differ- ence in favor of Panama.
Sidney from—			
New York	Miles. 9,784	Miles. 9,835	Miles. 49
New Orleans	9,219	9,070	-149
Plymouth	12,314	12,475	161
Average			20

"New Zealand is the only eastern place which can be reached more directly from Plymouth by way of the American Isthmus than by way

of the Suez Canal, but the distances to both Sidney and Wellington by the two routes (Panama and Suez) do not differ enough to determine the direction of the traffic. For Australian and New Zealand commerce the Panama and Nicaragua routes are equally convenient.

"Summarizing the preceding tables we find that San Francisco represents practically everything on the Pacific Ocean north of the equator and that to reach San Francisco the Nicaragua route has an advantage over the Panama route equivalent to 263 miles. For business with west coast of South America the Panama route has an average advantage of 442 miles. For business to points beyond the Pacific and south of the equator, which virtually consists of New Zealand and Australia, the Panama route has a slight advantage, but the advantage is so small and other routes are so feasible that this has no practical influence on the relative merits of the two schemes."

I then went beyond this in another study and tried to assign proportions to the different classes of traffic. This was an assumption of my own, and it can not be very accurate, because, as I have sometimes said, I know of nothing in which statistics are of as little value as are statistics about transportation before that transportation has come into existence. I will proceed:

"The previous studies have been based on a few terminal points without giving special consideration to the relative amount of traffic by the several routes; a further study should be made on this basis. The amount of traffic between the Atlantic and the Pacific ports of the United States will be regulated by various other conditions, especially interior transportation and the action of the transcontinental railroads. It seems approximately right to assume, however, that the trade of the United States Atlantic ports will be double that of the Gulf ports; that the trade of either Atlantic or Gulf ports with the regions represented by San Francisco, which includes Asia, will be double that of either of these with the west coast of South America; that the trade of European ports and of the Gulf ports with San Francisco and other west coast United States ports will be equal; that the trade of European ports with west coast ports of North and South America will be equal.

"Combining these figures and making the trade between Gulf ports and South American west coast ports the unit, we have the following relative amounts of the several lines of transportation. As before stated, New York represents the Atlantic United States ports, New Orleans the Gulf ports, Plymouth the European ports, San Francisco the North Pacific ports, and Cape Blanco the South American Pacific ports:

New York to San Francisco	4
New York to Cape Blanco	2
New Orleans to San Francisco	2
New Orleans to Cape Blanco	1
Plymouth to San Francisco	2
Plymouth to Cape Blanco	2
Total	13

"Of these all but the last represent traffic with the United States.

"To compare the relative distances by the two canals each of these numbers must be multiplied by the difference in favor of Panama or

Nicaragua, as given in Tables III and IV. If this is done we have the following results:

TABLE VIII.

	In favor of Pan- ama.	In favor of Nica- ragua.
New York to San Francisco, 4 by 233	932
New York to Cape Blanco, 2 by 472	944
New Orleans to San Francisco, 2 by 433	866
New Orleans to Cape Blanco, 1 by 272	272
Plymouth to San Francisco, 2 by 133	246
Plymouth to Cape Blanco, 2 by 582	1,164
	2,370	2,040

"This gives an average difference of 27 miles in favor of Panama.

"If we eliminate the last item as a traffic in which the United States has no interest, the average difference becomes 75 miles in favor of Nicaragua.

"These differences are so small as practically to put the two canals on an equality.

"All the above is on the assumption of the passage of each canal without delay for darkness or other interruptions.

"N. B.—These pages of tables are inserted by mistake and do not form part of those read. They are now removed, which explains the gap in page numbering."

The only conclusion that I can draw from all this is that there is practically no advantage in one route over the other.

The CHAIRMAN. If I get the statement correctly that you made, it is 500 miles on the Pacific side between Panama exit of the canal and Nicaragua.

Mr. MORISON. Five hundred and forty-three.

The CHAIRMAN. Then, if we want to shorten our coastwise line of trade, we would gain that distance by going through Nicaragua?

Mr. MORISON. You would gain that on the Pacific Ocean, but you would lose it by the time of going through the canal.

The CHAIRMAN. Now, all of the estimates that you made, it occurs to me, are made for steamers?

Mr. MORISON. Yes.

The CHAIRMAN. You make no allowance for sailing ships at all?

Mr. MORISON. No, sir.

The CHAIRMAN. Why do you drop them off?

Mr. MORISON. Because I do not believe that any sailing vessels are going to take either of those routes. There are practically no sailing vessels going through the Suez canal. Sailing vessels have courses of their own, which, as a rule, go a long way from land. There are certain routes where they do very well, and others where they do not, but where you can take a short course with a steamer I do not know of any route where a sailing vessel could do it at all.

The CHAIRMAN. Then you think the sailing ships of the United States, both on the Pacific and the Atlantic, are doomed to pass through the Straits of Magellan?

Mr. MORISON. No, sir; no sailing ship ever goes through the Straits

of Magellan. They go around Cape Horn or the Cape of Good Hope, depending on where they are going.

The CHAIRMAN. You think that is the future of the American sailing ship?

Mr. MORISON. Yes.

Senator HANNA. You do not mean to confine that to American sailing ships?

Mr. MORISON. No, sir. When a ship sails from San Francisco she sails southwest and goes away out into the Pacific Ocean, and then changes her course and proceeds toward Cape Horn.

The CHAIRMAN. But American sailing ships do sail in great numbers around the Cape of Good Hope?

Mr. MORISON. Yes.

The CHAIRMAN. Did you ascertain that that class of trade was increasing very much?

Mr. MORISON. No; I did not. Professor Johnson made the study about that.

Senator HANNA. From an economical standpoint, I know something of sailing ships and the commerce of the world. There has been an increase in sailing vessels, in the construction of them, a very few, but carrying very large cargoes. It would be a question of expense, of course, of economy, as to whether they could better afford to carry their cargos around with the extra time than they could afford to pay the tolls and the towing bills through the canal. If one was cheaper than the other they would go the cheaper way, provided the dangers and risks were not increased.

The CHAIRMAN. You have made no provisions in either canal for the advantage of sailing ships; you do not estimate that at all.

Mr. MORISON. No; I do not.

Senator HANNA. Well, the history of the transportation through the Suez Canal guided you to that conclusion because it is not used by sailing ships. That having the same relation with reference to the Cape of Good Hope that our canal would have with reference to Cape Horn, that would be a fair comparison?

Mr. MORISON. At present the grain from the Pacific coast is carried to Europe in sailing vessels. It is a four to five months' voyage; it is practically the only way that it can be taken to Europe without rehandling and various objectionable transfers.

Senator HANNA. Without a canal.

Mr. MORISON. I mean under present conditions. Then the present grain crop on the Pacific coast is handled in an entirely different way from what the Eastern grain crop is handled. That is due to the climate. The whole crop is sacked, and it is kept sacked in the fields until they are ready to ship it. With the canal done, a steamer would make the voyage from San Francisco to Liverpool, a 12-knot ship, in about twenty-five days.

Senator HANNA. Well, I entirely agree with that proposition in your original statement, that on the completion of the canal as a matter of cheap transportation and time considered, that steamers of 10 and 12 knots, of large burthen, would then drive the sailing vessels out of that grain trade, and I am strengthened in that opinion by the fact that on the Great Lakes there has not been a sailing ship built for years, and that all the coarse freights on the Great Lakes are now carried by steam vessels. Since we have got the 21-foot channel up there

the size of the vessels on the lakes have increased, in my experience, from 600 tons to 6,000 tons, which minimizes the expense of the cost of carrying them, so that a sailing vessel can not compete.

The CHAIRMAN. I will ask you now, Mr. Hanna, as you are making a statement about it, where do the steamers on the Great Lakes supply themselves with coal?

Senator HANNA. Everywhere where they load or unload their cargo.

The CHAIRMAN. But they do not have to transport coal to coaling stations in order to provide themselves on the trip?

Senator HANNA. Oh, yes; they do. There are coaling stations all along the Sault River. There are five there. There are coaling stations at the head of Lake Superior and at Milwaukee and at Chicago.

Senator MORGAN. Have the sailing ships disappeared from the lakes?

Senator HANNA. Yes; except those that were built years ago. There are none built now and there have been none building for years. A great many of them are turned into tow barges. All the sailing ships on the lakes are engaged in the lumber trade, and as they are lost or go out of use because of age they are neither rebuilt nor are new ones built in their place.

The CHAIRMAN. Why don't the steamers take the lumber?

Senator HANNA. They do; but sailing ships in existence, I say, that have been in the ore and other trades do not compete now at all.

The CHAIRMAN. Now, Mr. Morison, can you tell how the grain of the Pacific slope is now transported to the European markets, whether by sailing ships or steamers or railroad?

Mr. MORISON. Almost entirely by sailing vessels. Ten years ago I was in the habit of being on the Pacific coast a good deal. I have not been very much lately, but I think it has not changed.

The CHAIRMAN. They did not give up the sailing vessels for transportation of grain because it goes slow?

Mr. MORISON. It is an extremely long voyage, which would be a very difficult voyage for a steamer to make.

The CHAIRMAN. But they do not give it up and take the steamer in order to increase the speed of the voyage?

Mr. MORISON. No, sir.

The CHAIRMAN. They still adhere to the sailing ships.

Mr. MORISON. But that is an entirely different case.

The CHAIRMAN. That may be a different case, but it is the truth, isn't it?

Mr. MORISON. It is the truth; it is one of the few cases where sailing vessels have the advantage. There are certain routes in which sailing vessels can make almost as good time as steamers, where you get wind. If sailing vessels could go from Liverpool to New York as quickly as they can go from New York to Liverpool, I think they would still be carrying a large portion of the freight between New York and European ports.

The CHAIRMAN. They are carrying a large proportion of it now, are they not?

Mr. MORISON. No; but if sailing vessels could make the time westward that they can make eastward they would be still in the business.

The CHAIRMAN. That is owing to the winds?

Mr. MORISON. The winds and currents.

The CHAIRMAN. If you have any experience in it, the winds of the ocean are very permanent in their character, are they not?

Mr. MORISON. They are in certain latitudes, and in others they are not.

The CHAIRMAN. Take the trades.

Mr. MORISON. The trades can be relied on in certain latitudes, and that is one reason why sailing vessels have continued to this day in the commerce that goes around the Cape of Good Hope or around Cape Horn, in both of which routes they have to cross the Tropics twice.

The CHAIRMAN. Don't you think that availing themselves of that power they will still continue to spread their sails on the ocean?

Mr. MORISON. If they are going to cross the Tropics in that way.

The CHAIRMAN. You do not expect that sailing ships will stop because the steamship has got the run?

Mr. MORISON. No, not entirely; but as soon as they cease to have to cross the tropics twice, which would happen when the canal is built, as soon as they cease to do that, the advantage of the sailing vessel would disappear and the steamer would come right in.

The CHAIRMAN. Have you ever computed what proportion of the coastwise trade of the United States on the Pacific and the Atlantic coasts is done by sailing ships?

Mr. MORISON. No, sir. There is a special class of trade along the Atlantic coast done by sailing vessels largely. I do not think there is as much on the Pacific, but up to the present time the conditions have been very artificial conditions on the Pacific coast. Under our navigation laws it has been a pretty hard thing to get steam vessels for the coasting trade.

The CHAIRMAN. But all of these propositions to spend money for digging a canal at Panama or Nicaragua, according to the plan of the Isthmian Canal Commission, are made and established without reference to the use of sailing ships?

Mr. MORISON. They have not been considered as of sufficient importance to have much weight in the conclusion.

The CHAIRMAN. Very good. That is all I want to know.

Senator HANNA. You say they have not been considered?

Mr. MORISON. I say they have not been considered as having much weight. We considered them to the extent of deciding what weight was to be given to them.

Senator HANNA. Of course it is a very small percentage. I do not know of anything more that I care to ask.

Mr. MORISON. There is one thing that I would like to say before we go. I see that a previous witness has introduced a paper that I prepared on the subject of the Bohio dam. That paper was prepared with a view of bringing the matter before a collection of engineers for discussion, to see what criticisms could be made on what I considered a satisfactory solution of the dam problem at a very much less expense than the Commission's plan. It will be discussed at a meeting in New York on the 5th of next month. When I stated there that I considered the Commission's plan—I have not the paper here or I would give you the exact words—when I stated there that I considered that the Isthmian Canal Commission's plan involved very great difficulties, I certainly did not mean that it could not be done. My own judgment is that, if I was going to use a core wall, I should not put the core wall in by the use of the pneumatic process, but I should select a place where I should have to go deeper than 128 feet, and would use the method that has been used in sinking very deep foundations in the

rivers of India—that of dredging through wells. The paper was prepared for the purpose I have mentioned.

Senator HANNA. Of creating a discussion?

Mr. MORISON. It was prepared to bring forward the plan and have it discussed, and to get the opinions of engineers.

Senator HANNA. Is Mr. Menocal a member of the engineers' association?

Mr. MORISON. Yes. I noticed that Mr. Menocal criticises a portion of the estimate on the ground that the pneumatic work is put in at \$21.50 instead of \$29.50 a yard. The reason it is put at \$21.50 a yard is that the greatest depth is 60 feet instead of 128 feet, and I think that certainly justifies the reduction of \$8 a yard.

The CHAIRMAN. You have examined the blue prints with reference to the Bohio dam?

Mr. MORISON. Yes, sir; and I passed on that point as a member of the Panama Commission.

The CHAIRMAN. That involves something more than merely putting down a caisson.

Mr. MORISON. The caissons simply form the foundation of the core wall; that is all.

The CHAIRMAN. But the bottom of the river there, or the dam, is not uniform.

Mr. MORISON. Certainly not.

The CHAIRMAN. How do you supply the difference between one edge of the caisson and the other which is up a few feet higher?

Mr. MORISON. That is a perfectly simple thing. You fill it up with concrete or something of that order. I have done that again and again in bridge foundations.

The CHAIRMAN. So that one edge of the caisson would rest on the rock and the other on the concrete.

Mr. MORISON. Yes, sir.

The CHAIRMAN. That is your plan?

Mr. MORISON. That is their plan.

The CHAIRMAN. Do you approve of that plan?

Mr. MORISON. I have put in a lot of bridge piers that way, and it is perfectly legitimate.

The CHAIRMAN. I understood you to say a moment ago that if you had the building of the dam you would dredge it.

Mr. MORISON. If I had to build that kind of a dam with the core wall I should consider very carefully what was the best way to do it. I should remember my old teacher's instructions that if I had five minutes in which to solve a problem I had better spend three in deciding the best way; and my own present feeling is that the chances are I should find some way to do that without using the pneumatic process.

The CHAIRMAN. You do not approve in advance of that plan as being a sufficient plan?

Mr. MORISON. I think it is a plan for the purpose for which it is made; it is a plan that can be carried out in some way, and it is a plan which, so far as estimates are concerned, may certainly be considered to be at least as expensive as that on which the dam will be built.

Senator KITTREDGE. What did you say about ships using the Nicaragua Canal after dark?

Mr. MORISON. It can be done; it is a very bad climate, but it can

be done. My own belief is that large ships will not run at night, but that small ones will.

Senator KITTREDGE. How can you light it?

Mr. MORISON. You can light the banks, and every ship should be supplied with a special set of electric lights, and special instructions for the use of them.

Senator KITTREDGE. Would it not be necessary to have lights along the canal banks in addition to the lights that the ships would carry?

Mr. MORISON. Yes; there ought to be some, but that kind of buoy lights do not cost very much.

Senator HANNA. Gas buoys?

Mr. MORISON. Yes; they are not very expensive.

Senator HANNA. No; but they are very good; they are a great invention.

The committee then (at 4 o'clock p. m.) took a recess until Thursday, February 13, at 10.30 o'clock a. m.

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